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*"To the solid ground
Of Nature trusts the mind which builds for aye."*—WORDSWORTH.

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THE BOOK OF THE DEAD.

The Papyrus of Ani in the British Museum. The Egyptian text with interlinear transliteration and translation, a running translation, introduction, &c. By E. A. Wallis Budge, Litt. D., Keeper of Egyptian and Assyrian Antiquities. Printed by order of the Trustees, 1895. (London: Longmans, Kegan Paul, &c.)

PERHAPS one of the most attractive and popular departments of science is that which treats of the early customs and beliefs of primitive man. Within recent years considerable attention has been directed to this subject. Not only have specialists, such as Mannhardt, Waitz, Bastian, and Tylor, to mention a few prominent names, devoted themselves to the collection and classification of material, but a great body of the reading public have followed their labours with intense interest, and have embarked on a course of original inquiry on their own account. The chief reason for this widespread study of comparative religion is to be sought in the fact that no demands are made on the student for any special training in order that he may appreciate its methods and results. Let him but have the passion of the collector and a love for his subject, and he is fully equipped for his work; all he requires beside are books that will yield reliable information concerning the folk-lore or superstition of any early or primitive race. Readers of NATURE, therefore, will be interested in hearing some account of a remarkable work, recently published by the Trustees of the British Museum, which deals with the religion of the oldest nation in the world whose records have survived to the present day.

The nation to which we refer, it is needless to say, are the Egyptians, whose civilisation on the banks of the Nile stretches back into a remote antiquity. Both the art and literature of this people were in the main the product of their religious belief in a future existence; what we possess of the former we owe to its preservation in the tomb, while a great part of the latter has come down to us in a body of religious compositions to which Egyptologists have given the comprehensive title of "The Book of the Dead." It is with "The Book of the Dead" that the work in question deals. In the year 1888 the Trustees of the British Museum acquired the largest and most perfect specimen of this composition as preserved by that class of papyri which date from the second half of the eighteenth dynasty (about B.C. 1500–1400). About four months ago the Trustees published a second edition of the *facsimile* of the papyrus, and now Dr. Wallis Budge, the Keeper of Egyptian and Assyrian Antiquities, has produced a volume dealing exhaustively with the contents of this unique document.

It would be impossible to treat at any length in a short review the many problems discussed in the work before us. We can, however, briefly indicate its general scope and contents. Dr. Budge has given a transliteration and literal translation of the hieroglyphic text, arranged interlinearly, which will be of great value to the student. This is followed by a running translation, together with a description and explanation of the various vignettes with which the papyrus is profusely illustrated—a portion of the work which will be welcomed by the general reader. Perhaps of even greater importance, however, is the Introduction. Here the author has traced in detail the history and growth of "The Book of the Dead," from its first appearance on the Pyramids of the fifth dynasty to its latest hieratic recension in the early centuries of the Christian era. From the hands of the priests of Hierapolis we follow the work to Thebes, where we first find it divided into definite sections or chapters, each with its distinctive title. Thence, through the closely allied version of the twentieth dynasty to Saïs, where each chapter received its definite place in the series, and the order there introduced continued in use down to the Greek occupation of the country. Having laid before the reader a critical digest of the external history of the work, Dr. Budge then turns to internal questions, and proceeds to summarise the chief aspects of Egyptian belief, supporting each of his theses with citations from the native literature. He treats at length of the legend of Osiris, so closely connected with the doctrine of eternal life, and thence passes to the Egyptian idea of God. This section is followed by a detailed

description of the gods of "The Book of the Dead," and of the principal geographical and mythological places mentioned therein. The practical side of Egyptian worship then engages our attention, and we see the priest performing the complicated system of ritual and ceremony that accompanied the burial of the dead; and, the ground having thus been cleared, one passes on to a consideration of the Papyrus of Ani itself. Ani, in whose honour the work was written, was chancellor of the ecclesiastical revenues and endowments of Abydos and Thebes. From the fact of his exalted official position, therefore, we may, with Dr. Budge, regard his Papyrus as "typical of the funeral book in vogue among the Theban nobles of his time."

In the course of the Introduction Dr. Budge has admirably distinguished the uses of the Egyptian word *neter*, which correspond to a transition from anthropomorphic and polytheistic ideas to a lofty monotheism. The derivation of the word is a moot point among Egyptologists, though all agree in rendering the word by "god." Its original signification, however, may be disregarded, for it does not affect the later history of the word, with which we are at present concerned. Whatever its origin, there is no doubt that the singular *neter* is often used to express an entirely different conception to that conveyed by *neteru*, its plural, the former being employed to designate a supreme god, the latter a number of powers and beings, which were held to be supernatural, but were finite and endowed with human qualities and limitations. The truth of this will be evident to any one who will read through the passages collected by Dr. Budge in support of his contention. Dr. Budge cites the similar difficulty that attaches to the interpretation of the Hebrew word *élohîm*, a comparison that might be dwelt on with advantage. One point of difference, however, may here be noted. In the history of the Hebrews we can point to the exact period when the radical change from polytheism to the belief in one god took place. With the rise of the prophets in the ninth century B.C. the nation imbibed the loftier conception, and they assimilated the prophetic teaching with such effect, that, during the post-exilic collection of the national literature, all traces of their former polytheism were as far as possible obliterated. In their literature, therefore, as it has reached us, the earlier national beliefs have survived only in indirect allusions and in the form of single words. With the Egyptians, on the other hand, this change in conception can be ascribed to no particular epoch. We find the idea of a supreme god in existence as early as the fifth dynasty; yet throughout the whole period of Egyptian history there existed side by side with it the lower conception of half-human deities, and the belief in an eternal and infinite god was not considered inconsistent with legends concerning lesser deities, who could eat and drink, and, like men, grew old and died.

To this tolerance, or rather attachment, displayed by the Egyptians for their legends and traditional beliefs, students of comparative religion at the present day owe a lasting debt of gratitude. For many of the legends preserved in late papyri have been handed down unchanged from earlier times, while the earlier monuments themselves have escaped the fury of the iconoclast. We will refer to one such legend cited by Dr. Budge. In a text of the fifth dynasty, the deceased king Unas is described in the form of a god as feeding upon men and gods. He hunts the gods in the fields, and, having snared them, roasts and eats the best of them, using the old gods and goddesses for fuel; and, by thus eating their bodies and drinking the blood, he absorbs their divine nature and life into his own. Many parallels to this quaint legend might be cited from the primitive beliefs of other races.

We cannot conclude without a reference to the unpolemical spirit in which the book is written, which is perhaps the result of a scientific training in Semitic languages and literature having been brought to bear on the difficult problems of Egyptian religion. Throughout the work it is evident that one of the chief aims of Dr. Budge has been to assist the reader to understand the evidence which documents nearly 7000 years old are here made to produce, and to judge of its value for himself. To the anthropologist and the student of comparative religion we, therefore, believe the work will be equally valuable.

THE POLLINATION OF FLOWERS.

Over de Bevruchting der Bloemen in het Kempisch Gedeelte van Vlaanderen. By J. Mac Leod. With 125 Figures. (Gent: Vuylsteke, 1894.)

THIS book is prefaced with a historical introduction which traces the study of the biology of flowers from the appearance of the work of Camerarius in 1691 to the present day. Not only does the author give an account of the work of the various writers, but he also devotes a good deal of space to criticising their conclusions, and comparing them with one another. Of these criticisms, it may be noticed, that he considers that too much importance has been ascribed to the colours of flowers in attracting insect-visitors, and he adduces several facts in support of his view. From these examples it appears that there are certainly some cases in which the bright colours of flowers have not got the object of attracting insects; yet surely in the vast majority of cases, whether the development of bright colours was primarily for this object or not, the showy floral leaves act as advertisements to catch the eye of wandering insects. As the author substitutes no definite theory to account for the colouration of flowers, it seems probable that the old view will hold its ground.

The greater part of the book (about 430 pp.) is taken up with an account of the floral mechanisms of the plants found in East and West Flanders. The mechanisms of a large number of species are carefully described, and the descriptions are illustrated by many good woodcuts, in great part original, in a few cases borrowed from other authors. At the conclusion of the description of each species a list of their insect-visitors is given; these lists appear to be very complete, and will doubtless be useful for reference.

The latter part of the work is largely taken up with an endeavour to find a parallelism between the annual evolution of the various classes of plants and insects, classified according to their mutual biological relations. But the author admits that this attempt has not been successful.

The last section to which we would call attention is that which contains a description of a theory to explain why some plants are adapted for direct fertilisation, and others for crossed fertilisation. According to this theory, entomophilous plants have to make certain sacrifices in order to attract visitors in the shape of the substances needed in the formation of nectar and various perfumes, which are, to a large extent, drawn from the reserve-materials contained in the plant at the time of flowering. If these reserve-materials are present in considerable quantities, the plant will be able to produce much nectar, &c., and will attract many insects, and become adapted to crossed fertilisation. If, on the other hand, it has but little of these stores, it will be able to expend very little in attracting insects, but will have to keep the great part of its scanty stores for the maturation of its fruits and seeds. The consequence will be that the flowers of these latter plants will be but little visited by insects, and will become adapted to self-fertilisation. The author, while he admits that this theory is insufficient to explain certain observations, yet maintains that it is more general in its application than Warming's idea expressed with regard to the flora of Greenland. According to this latter author, crossed fertilisation may be considered the rule in the case of those plants which multiply rapidly by vegetative reproduction, while plants without this second method of reproducing their kind, and which must necessarily bring their seeds to maturity, are most usually adapted to self-fertilisation. It is, however, most probable that neither of these theories should be regarded as in itself giving all the determining causes for a plant becoming adapted to crossed or self-fertilisation, but as only expressing two of, it may be, many factors which are at work in moulding any given plant for one form of fertilisation or another. H. H. D.

OUR BOOK SHELF.

Emile Levier. A travers le Caucase. Notes et Impressions d'un Botaniste. 8vo. pp. 348. (Paris: Libraire Fischbacher.)

DR. LEVIER accompanied his botanical friend, Signor Stephen Sommier, on a tour through the Central Caucasus in 1890, the object being mainly to collect and study the flora of the mountains. The letters which he sent to his friends recording his impressions were published in a magazine without his knowledge, although not written for the public, and the present volume is practically a republication of the letters, edited by the author, and illustrated by numerous sketches and reproductions of photographs. Amongst the latter are several of Signor Vittorio Sella's fine pictures of Caucasian scenery, which, however, are not done justice to in the process blocks. The botanical results of the journey have been published for the most part in the *Bulletin* of the Italian Botanical Society, and only a list of the sixty-nine new species found is given in the book, such references to botany as occur in the text, though full of interest and presenting some acute generalisations, by no means preponderating over the miscellaneous observations of an intelligent tourist, and the pleasantly narrated incidents of travel. A list of thirty-seven species of lepidoptera collected by Dr. Levier is also given.

The two botanists were accompanied by an Italian peasant as hunter, cook and general assistant; and together they experienced few difficulties and no danger on their journeys through unfrequented regions for four months. After some excursions in the neighbourhood of Batum and of Tiflis, they started from Kutais for the journey across the range, going up the valley of the Rion and across the Latpari Pass into Swanetia. After traversing the valleys of Swanetia and Abkhasia, and making an excursion up the valley of the Kukurtli on the western slope of Elburz, they reached the northern plain by the valley of the Kuban. They returned to Tiflis by the coach road from Vladikavkas through the Dariel Pass heavily laden with more than ten thousand botanical specimens, the drying of which was a never-failing source of surprise and amusement to natives and Russian officials alike.

The spirit of holiday and nature-worship breathes through the whole book. Rarely, we believe, is a traveller in untrodden ways so able to appreciate to the full the delights of his surroundings as this light-hearted Swiss physician, whose high spirits and good-humour retain contagious qualities even through the pages of his book.

H. R. M.

Science Readers. By Vincent T. Murché. Books i. to iii. (London: Macmillan and Co., 1895.)

IN elementary schools where the rudiments of knowledge about properties and things are taught, these books may be introduced with advantage as reading books. The style is conversational, and every effort appears to have been made to convey the information in simple language, as well as to make it interesting.

LETTERS TO THE EDITOR.

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.*]

Origin of the Cultivated Cineraria.

IN the recent discussion at the Royal Society, I used as an illustration of the amount of variation which could be brought about under artificial conditions in a limited time, the case of *Cineraria cruenta*, which I regarded as having given rise to the cultivated Cineraria.

This Mr. Bateson describes as "misleading."

I have read all he has to say, and, with the assistance of competent members of my staff, have carefully examined authentic specimens of all the species he names as having had a share in the parentage of the Cineraria.

Those species, if I understand him rightly, are four in number: *cruenta*, *aurita*, *populifolia* and *lanata*. They were all introduced into English horticulture, through Kew, between 1777 and 1780, and were figured and described by L'Héritier in his "Sertum Anglicum."

A technical discussion of the subject would necessarily take up a good deal of space, and would not be very interesting to readers of NATURE. Mr. Bateson refers to De Candolle's "Prodromus." It will be sufficient, perhaps, to say that had he studied that authority with care, he would have found that while *cruenta* is, like the modern Cineraria, herbaceous, *aurita*, *populifolia* and *lanata* are shrubby species. Further, while the modern Cineraria retains the exact foliage of *cruen a*, that of *aurita* and *populifolia* resembles the foliage of the white poplar; "folia populi albæ." Apart from the additional fact that *populifolia* has yellow flowers, I think I may confidently appeal to even the non-botanical eye as to whether the modern Cineraria exhibits anything of the white poplar character about it. As to *lanata*, its general aspect is sufficiently indicated by its specific name. It is represented by numerous specimens in No. 4 House at Kew, where Mr. Bateson may inspect it. He will probably then regret, for the sake of his reputation as a naturalist, that he committed himself to print on a subject on which he evidently possesses little objective knowledge.

I may add that in the discussion at the Royal Society, Mr. Bateson asserted to my surprise that the cultivated varieties of the *Camellia* could be distinguished by their leaves alone. I

interjected a doubt, but next day I carefully examined a large number of specimens here with a member of my staff, and we totally failed to confirm Mr. Bateson's statement.[1]

W. T. THISELTON-DYER.

Royal Gardens, Kew, April 29.

The Unit of Heat.

MR. GRIFFITHS, in a recent communication to the Royal Society, has called attention to the indefiniteness attending our present knowledge of the heat unit. In this connection I would wish to suggest—what indeed has long been present in my mind—that a unit of heat other than the present calorie is desirable. The present thermal unit is highly arbitrary, as well as most difficult of verification. This is true, whether we take the temperature at which the calorie is to be measured as 4° C. or 15° C. or as the temperature of minimum specific heat of water. The calorie owes its perpetuation to the method of mixtures—a laborious and inaccurate method of calorimetry—and dates from a period when the variations in the specific heat of water were not held of account.

If we do adhere to a specific heat of water calorie, it will be necessary to proceed as in the determination of the standard metre; obtain the more or less inaccurate measure of the primary unit in terms of some more accessible quantity.

My suggestion is that we start with an accessible unit. I think the latent heat of steam at the standard pressure has first claim. One gramme of saturated steam at 760 m.m. might be assumed to give up the unit quantity of heat in becoming water, without change of temperature. This unit might be called a therm, in order to avoid confusion with the existing unit. The specific heat of water would then stand as about 1·8 milli-therms. The larger value of the new unit commends itself as being more applicable to the problems of applied science; which, indeed, may be inferred from the fact that engineers often understand by the term calorie the kilogramme-degree.

I am aware that the change proposed is a radical one; but an appreciable change is better than a vexatious correction, and we know now that revision and change are inevitable.

In the definition of the proposed unit we replace the unreliable thermometer by one of the most trustworthy of instruments—the barometer; and our quantities of heat may be determined by the chemical balance, and, at 760 m.m., read directly upon the weights. We are sure of the purity of the material.

Trinity College, Dublin. J. JOLY.

The Study of Earthquakes in the South-East of Europe.

IN two recent notes in NATURE (vol. li. pp. 180, 468) attention has been drawn to the foundation by the Ottoman Government of a geodynamic section of the Imperial Meteorological Observatory at Constantinople. The new department has been placed under the direction of Dr. G. Agamennone, who for several years held a similar office at Rome, and who is well known to seismologists for the valuable work performed by him in Italy.

Not content with the foundation of a seismological observatory, Dr. Agamennone has also undertaken the organisation of earthquake studies throughout the Ottoman Empire, and he is anxious to extend this very important branch of his work so as to include the entire district within and bordering the eastern end of the Mediterranean. As there must be many readers of NATURE who are able, either directly or indirectly, to aid him in this attempt, I should be grateful if you would allow me to recommend it to their attention and support. Dr. Agamennone's address is "Observatoire Impériale Météorologique, Constantinople (Pera)."

That one of the finest seismic regions of the globe should at last attract the organised study it deserves, and that the initiation of the requisite observations should have fallen into hands so experienced and capable, will be matters of gratification to those who are interested in the progress of seismology. No less desirable would it be that all the results of such observations should be contained in the pages of a single journal, and Dr. Agamennone's publication of a monthly seismic bulletin, of which the first two numbers have already been issued, is an additional reason for the concentration of records from the different countries concerned in the Turkish Office.

Birmingham, April 19. CHARLES DAVISON.

[1] This and the absence of variation from the feral form in the foliage of the cultivated Cineraria, are covered by the principles laid down by Darwin in "Animals and Plants under Domestication," vol. ii, pp. 217-220.

Uniformitarianism in Geology.

IN reference to Prof. Judd's excellent statement of the position of the uniformitarian, allow me to call attention to an argument which tends to show that, so far as earthquakes and volcanic eruptions are concerned, catastrophes may be of greater magnitude now than in earlier geologic times.

The violence of an explosion will depend largely on the amount of confinement and pressure to which the exploding compounds are subject, as well shown in the case of Kilauea—where there is a constantly open vent and no violent eruptions—as contrasted with the numerous catastrophic explosions of long dormant volcanoes whose vents had become sealed up with cores of solid lava. But it is admitted that the crust of the earth has been growing thicker during all geological time. It is therefore almost certain that, in the remoter epochs volcanic phenomena were more frequent but less violent than they have become now that the crust is thicker, and, in its lower portions, at all events, denser and more consolidated. The usual argument, that, because the interior of the earth was somewhat hotter in early times therefore volcanic phenomena were more violent, appears to me to be entirely fallacious. The liquid matter immediately below the crust would have been at the same temperature then as it is now; and if there were a more abundant supply of aqueous vapour and other gases, the thinner and more permeable crust would have allowed of their constant and comparatively easy escape.

I do not remember to have seen this consideration referred to in any discussion of the question, and I therefore submit the argument to the judgment of physical geologists.

ALFRED R. WALLACE.

Research in Education.

PROF. ARMSTRONG'S trenchant indictment of the present methods of teaching science, is a little too much akin to Carlyle's fulminations against things in general—destructive but not constructive. Probably all good teachers are agreed upon the pernicious futility of the text-book and lecture-room cram system, and are in thorough accord as to the educational value of practical work; and are waiting only to learn or discover the best system of employing it. To this end destructive criticism helps but little. What is wanted is some definite scheme of work constructed by masters of practical instruction. Prof. Armstrong does certainly advocate what may be termed the "research method"; but it does not elucidate the question much, for it is difficult to understand how far he would extend this method. Would he, for instance, never mention Dalton's laws to students until, by a series of analyses, they were in a position to discover them for themselves? Or in the case of specific heat, how much information should be given before the beginners are set to investigate the phenomena alone? There are two ways of learning practically physical and chemical truths, either by repeating methods which have been explained and demonstrated, and then verifying each step by actual contact with real objects, and so acquiring real knowledge of fact and the application of theory, or by struggling to the truth by a process of trial and error. That the latter process, when successful, is the more stimulating to the intellect may be admitted, but that it is practically possible must be doubted. In introducing any new subject to the mind, surely broad outlines should be given first, and details filled in afterwards; observation requires teaching as much as any other faculty. Tyndall tells this story of Faraday. As Tyndall was about to show the latter an experiment, Faraday laid his hand on his shoulder and said, "Wait a minute; what am I to look for?" The application is plain—even Faraday felt the advantage of having the observer fore-armed.

Beginners know not what to observe, and cannot fashion experiments for themselves, and therefore it seems more rational, that students should have the recognised methods of science explained and demonstrated to them, and then be caused to repeat the necessary operations practically, numerical details being varied as in mathematical exercises. When thus equipped with sound theoretical knowledge and fair manipulative dexterity, they will be in a position to embark upon "research"; for they will then have acquired some power of observation, accuracy, and the faculty of making inferences. The "research method" *ab initio* appears like an attempt to teach a child to read before he knows his letters. I am fully conscious of my audacity in venturing into the lists, and am not ignorant of the sort of folk who "madly rush where angels fear to

tread"; but if I can elicit some definite scheme from Prof. Armstrong, I shall regard my own dialectic annihilation as a small price to pay for the ultimate gain. D. S. T. GRANT.

Chemical Laboratory, Lahore, Punjab.

A Lecture Experiment.

To show that chlorine will attack mercury, some mercury was shaken up in a covered gas jar filled with chlorine. On shaking, the sides of the jar and also the cover-glass became coated with a continuous film of mercury, as though the inside were silvered. After a short time, the film was eaten through, and patches of the white chloride produced. I have not seen this effect noticed in books, so it may be worth while to call attention to it.

C. J. WOODWARD.

Municipal Technical School, Birmingham, April 25.

VITALITY OF SEEDS.

THE duration of the vitality of seeds is perhaps the most important of the various phenomena of plant-life, especially when considered in connection with the introduction into a country of the economic plants of other countries. It is a subject that has engaged attention from very early times, and the literature relating thereto is considerable. Much of this, however, is of a traditional and unpractical character; but even if we confine ourselves to the demonstrable, or demonstrated, the subject is almost inexhaustible. There is such an infinity of variety in the behaviour of seeds under different conditions, that it is impossible in a short account, such as this must be, to do more than convey a general idea of the subject. Perhaps the best way to treat the question, apart from technicalities, is to consider the vitality of seeds under ordinary, and under extraordinary, conditions. In the development and germination of seeds, there is, in a sense, usually a period of gestation and a period of incubation, as in oviparous organisms of the animal kingdom; and the duration of these periods is within definable limits, under ordinary conditions, though seeds do not exhibit the same fixity of time in regard to development and vitality as eggs. The embryo of a seed is the result of the impregnation of the female ovum in the ovary or young seed-vessel, by the male element, generated in the anthers; and in the mature state this embryo may fill the whole space within the skin, or testa, of the seed, as in the bean and acorn; or it may be a comparatively minute body, as in wheat, maize, and other cereals; the rest of the seed being filled with matter not incorporated in the embryo. The difference is one of degree in development. In the one case, the growing embryo has absorbed into its own system, as it were, before germination or the beginning of the growth of the embryo into a new plant, the whole of the nutrient material provided in the seed for reproduction; whereas, in the latter case, the process of absorption and utilisation of the "albumen," or nutrient matter, takes place after the seed is detached from the parent plant, and during the earliest stage of growth of the new plant; so that the plant is nourished until it has formed organs capable of assimilating the food obtainable from the atmosphere and earth. Between these two extremes of development of the embryo, or future plant, before organic connection with the parent ceases, there is every conceivable degree and variety; and, as will presently be explained with examples, some plants are viviparous, in the sense that the embryo commences active life before being severed from the parent, so that when this occurs the plant is in a position to draw its sustenance from unassimilated or inorganic materials. Now it is a curious and unexplainable fact that certain seeds exhibiting the extremes of embryonal development, instanced in the bean and wheat, are equally retentive of their germinative power. The longevity, if it may be so called, of seeds is exemplified in "exalbuminous" seeds as well as in "albuminous" seeds of every degree. It should be mentioned, however, that the difference is not so much one of assimilation or development as of the earlier or later transfer of the nutrient matter of the seed to the embryo or plantlet. Assuming the perfect maturation of a seed, certain conditions are necessary to quicken its dormant vitality; and the two principal factors are heat and moisture, varying enormously in amount for different plants, and acting much more rapidly on some seeds than on others, even when the amount required is much the same. Neither under natural nor under artificial conditions will some seeds retain their vitality more than one season; and all the resources of the accumulated experience of seed-importers from distant countries are insufficient in some cases to maintain their vitality. It is not altogether because the interval between the dispersal and the germination of the seed, under ordinary conditions, is necessarily longer; but rather because in the one case the conditions under which a seed will germinate are much more restricted than in the other. Let us now examine the natural conditions under which seeds are commonly produced and dispersed, in relation to the retention of their vitality; and we shall learn how much more it depends on their nature, or natural means of protection, than on the seasons. An oak tree sheds its acorns in autumn, and the leaves which fall afterwards afford them some protection from frost and excessive dryness. But the leaves might be blown away from one spot, and the acorns exposed to intense frost or drought, either of which will speedily kill them. In another spot the leaves may drift into thick layers, with an excessive accumulation of moisture, causing decay of the underlying acorns; and there are many other unfavourable conditions which may destroy the vitality of the acorn. It is apparently impossible, however, to preserve an acorn's vitality by any artificial means for more than one season.

The scarlet-runner bean loses its germinative power on exposure to comparatively slight frost, the degree depending upon the amount of moisture in it; yet it will retain its vitality for an almost indefinite period under favourable artificial conditions. In both of the examples given, germination would naturally follow as soon after maturation as the conditions allowed. The seeds of the hawthorn behave differently. Each haw contains normally three to five seeds, every one of which is encased in a hard, bony envelope, in addition to its proper coat or testa. Committed to the earth, and under the most favourable conditions, these seeds do not germinate till the second year, and often not so soon. In this instance prolongation of vitality is probably due in some measure to the protective nature of the shell enclosing the seed.

Returning to seeds in which the embryo or plantlet forms only a very small part of the whole body, wheat may be taken as a familiar and easily observed illustration of a seed, the vital energy of which requires very little to stimulate it into active growth; and yet this same seed, having no special protection in the way of coating, will retain its vitality as long, perhaps, as any kind of seed, if not under the influence of moisture. The primary condition to the preservation of vitality in a seed is perfect ripeness. Unripe seeds of many kinds will germinate and grow into independent plants if sown immediately after removal from the parent. The facility with which immature wheat will germinate is most disastrously exemplified in a wet harvest, when the seeds will sprout while the corn is standing or in sheaf; thus destroying more or less completely the value of the grain for flour, as the starch or flour is consumed in the development of the embryo, or what is left is so deteriorated by chemical change that it is not good for food. There is perhaps no other seed more susceptible to moisture, and none less affected by dryness, or by heat or cold in the absence of moisture.

The kind of vivipary exhibited by the wheat is occasionally observed in various other plants; and sometimes the seeds of pulpy fruits germinate in the fruit. There is also a class of plants in which vivipary is normal. Prominent in this class are the mangroves (*Rhizophoreæ*, &c.) of muddy sea-shores in the tropics. In these plants there is a remarkable adaptation to conditions, which ensures their reproduction. From the very inception of the embryo there is no apparent interruption of active vitality in its development and germination. In the earliest stage the cotyledons or seed-leaves are formed, and the radicle or future primary root is represented by a very small point. When the former have attained their full development, which is not great, the latter begins to grow and rapidly increases in size. Each fruit or seed-vessel, it should be mentioned, contains only one seed, the rootlet of which points to the apex of the fruit. Soon this rootlet pushes its way through the apex of the fruit, and grows into a spindle-shaped body of great density and length; the cotyledons or seed-leaves remaining partly inside the fruit, and acting as an organ of absorption from the parent plant to nourish the seedling. In *Rhizophora mucronata* this radicle attains a length of two to three feet, and the seedling eventually falls, and by its own weight penetrates and sticks in the mud, leaving the fruit, containing the exhausted cotyledons, attached to the tree, where it dries up. Another singular adaptation to conditions is the vital development of the seeds of aquatic plants which ripen their seeds on or under water. *Vallisneria* is a remarkable instance of this. The unisexual flowers are formed under water; the female on long coiled stalks, which at the right period uncoil, and the flower rises just above the surface of the water. Simultaneously the short-stalked male flowers are detached from the base of the leaf-stalks, and also rise to the surface. After impregnation has taken place, the stalk of the female flower coils up again, and draws the seed-vessel down under water, where the seeds ripen.

It has been explained that heat, moisture, and air are necessary to the germination of seeds, varying immensely for different seeds. We come now to the behaviour of certain seeds under the influence of an unusual or unnatural amount of moisture, heat or cold, especially in relation to the length of the duration of the exposure to any one of these factors. It has been proved beyond dispute, by actual experiment, that the vitality of certain seeds, notably various kinds of bean and convolvulus, is not impaired by immersion in sea-water—or rather floating and partially submerged—for a period of at least one year; and that after having been kept quite dry for two or three years. Plants are actually growing at Kew from seeds treated as described; and some years ago several seeds of *Entada*, cast ashore in the Azores, whither they had been transported by the Gulf Stream, were raised at Kew. So far as at present known, all the seeds that will bear very long immersion without injury have an intensely hard, bony, or crustaceous coat, that would withstand boiling for a minute or two without killing the embryo. Yet it is difficult to understand this power of resistance, especially after being kept dry for a long time. This imperviousness to water explains the wide distribution of many sea-side plants, the seeds of which are conveyed by oceanic currents. How long such seeds would retain their vitality in water is uncertain, because experiments have not reached the limit. Many readers will remember Darwin's experiments in this connection; but it should be borne in mind that they were chiefly with seeds of plants not at all likely to be dispersed by the sea.

It has already been stated that some seeds will bear immersion in boiling water for a short time, and gardeners occasionally practise this treatment to accelerate the germination of hard-coated seeds. But seeds of all kinds will bear for a considerably longer period a much higher dry temperature than soaking in water of the same temperature. It is recorded, by trustworthy authorities, that the seeds of many plants—poppy, parsley, sunflower, and various kinds of grain, for instance—if perfectly dry, do not lose their vitality when subjected to a temperature of 212° F. for forty-eight hours; and for shorter periods to a much greater heat. The result in most cases, though not all, is a considerable retardation of germination. Dry grain is equally impervious to cold. In 1877, seedling wheat was exhibited at the Linnean Society that had been raised at Kew from grain that had been exposed to the intense cold of the Arctic expedition of 1874 to 1876. The next question that arises is: how long do seeds retain their vitality when stored in the ordinary ways adopted by dealers? As a rule, seedsmen and gardeners prefer new seed, because a larger percentage germinates; and mixing old seeds with new, tells its own tale in irregular germination. Nevertheless, there are many seeds that retain their vitality from five to ten years sufficiently well to be depended upon to yield a good crop. Old balsam seed, other things being equal, has the reputation of yielding a larger proportion of double flowers than new; and some gardeners consider that cucumber seed of four or five years of age gives better results than the seed of the previous year. As already mentioned, perfectly ripened seed will retain its vitality longer than imperfectly ripened seed. In illustration of this, we note that carrot seed grown in France retains its germinative power, on the average, longer than English-grown seed, owing to climatal differences.

There is one other natural condition in relation to the vitality of seeds that should be mentioned; that is, the duration of the vitality of seeds on the mother plant. Some of the Australian *Proteaceæ*, and some of the fir trees, especially North American, bear the seed-vessels containing quick-seeds of many successive seasons; and only under the influence of excessive drought or forest fires do they open and release the seed. Rapid forest fires are often not sufficient to consume the cones, but sufficient to cause them to open and free the seed for a succession of trees. The unopened cones of thirty years have been counted on some fir trees; and it is averred that the first seed-vessels of some proteaceous trees do not open to shed their seed, under ordinary conditions, until the death of the parent plant, so that a tree may bear the accumulated seed of half a century or more.

Finally, a few words respecting the extreme longevity attributed to certain seeds. The reputed germination of "mummy wheat," from two to three thousand years old, has been the theme of much writing; but the results of careful subsequent experiments with grain taken from various tombs do not support the doubtless equally conscientious, though less skilfully conducted, experiments, supposed by some persons to have established the fact of wheat of so great an age having germinated. Indeed it is now known that the experiments mainly relied upon to prove this long retention of vitality were falsified by the gardener who had charge of them. Nevertheless, there is no doubt that some seeds do retain their vitality for a very long period, as is proved by numerous well-authenticated instances. Almost every writer on physiological botany cites a number of instances. Kidney beans taken from the herbarium of Tournefort are said to have germinated after having been thus preserved for at least 100 years. Wheat and rye are also credited with having retained their vitality for as long a period. Seeds of the sensitive plant (*Mimosa pudica*) kept in an ordinary bag at the Jardin des Plantes, Paris, germinated freely when sixty years old. A long list might be made of seeds that have germinated after being stored for twenty-five to thirty years. If seeds retain their vitality for so long a period as this under such conditions, it is quite conceivable that seeds buried deep in the earth, beyond atmospheric influences, and

where there was not excessive moisture, might retain their germinative power for an almost indefinite period; and the fact that plants previously unknown in a locality often spring up where excavations have been made, bear out this assumption. The same thing happens in arable land, should the farmer plough deeper than usual; and deeper tillage, which would otherwise be beneficial, is often avoided on this account. A careful writer like Lindley states, though without qualification, that he had raspberry plants raised from seed taken from the stomach of a man, whose skeleton was found thirty feet below the surface of the ground. Judging from coins found at the same place, the seeds were probably 1600 or 1700 years old. One more example of seeds germinating that are supposed to have been buried some 1500 to 2000 years. About twenty years ago, on the removal of a quantity of slack of the ancient silver mines of Greece, several plants sprang up in abundance previously unknown in the locality. Among these was a species of *Glaucium*, which was even described as new; and it is suggested that the seed may have lain dormant for the long period indicated. But there is not the amount of certainty about any of these assumed very old seeds to convince the sceptical or to establish a fact. It remains yet for somebody to institute and carry out careful investigations where excavations are being made.

W. BOTTING HEMSLEY.

TERRESTRIAL HELIUM (?).

AT the meeting of the Royal Society on Thursday last (April 25), two papers dealing with the nature of the gas from uraninite were presented. We print both papers in full.

ON A GAS SHOWING THE SPECTRUM OF HELIUM, THE REPUTED CAUSE OF D_3, ONE OF THE LINES IN THE SPECTRUM OF THE SUN'S CHROMOSPHERE.[1]

In the course of investigations on argon, some clue was sought for, which would lead to the selection of one out of the almost innumerable compounds with which chemists are acquainted, with which to attempt to induce argon to combine. A paper by W. F. Hillebrand, "On the Occurrence of Nitrogen in Uraninite, &c." (*Bulletin of the U.S. Geological Survey*, No. 78, p. 43), to which Mr. Miers kindly directed my attention, gave the desired clue. In spite of Hillebrand's positive proof that the gas he obtained by boiling various samples of uraninite with weak sulphuric acid was nitrogen (p. 55)—such as formation of ammonia on sparking with hydrogen, analysis of the platinichloride, vacuum-tube spectrum, &c.—I was sceptical enough to doubt that any compound of nitrogen, when boiled with acid, would yield free nitrogen. The result has justified the scepticism.

The mineral employed was cleveite, essentially a uranate of lead, containing rare earths. On boiling with weak sulphuric acid, a considerable quantity of gas was evolved. It was sparked with oxygen over soda, so as to free it from nitrogen and all known gaseous bodies except argon; there was but little contraction; the nitrogen removed may well have been introduced from air during this preliminary experiment. The gas was transferred over mercury, and the oxygen absorbed by potassium pyrogallate; the gas was removed, washed with a trace of boiled water, and dried by admitting a little sulphuric acid into the tube containing it, which stood over mercury. The total amount was some 20 c.c.

Several vacuum-tubes were filled with this gas, and the spectrum was examined, the spectrum of argon being thrown simultaneously into the spectroscope. It was at once evident that a new gas was present along with argon.

Fortunately, the argon-tube was one which had been made to try whether magnesium-poles would free the argon from all traces of nitrogen. This it did; but hydrogen was evolved from the magnesium, so that its spectrum was distinctly visible. Moreover, magnesium usually contains sodium, and the D line was also visible, though faintly, in the argon-tube. The gas from cleveite also showed hydrogen lines dimly, probably through not having been filled with completely dried gas.

On comparing the two spectra, I noticed at once that while the hydrogen and argon lines in both tubes accurately coincided, a brilliant line in the yellow, in the cleveite gas, was nearly *but* not *quite* coincident with the sodium line D of the argon-tube.

Mr. Crookes was so kind as to measure the wave-length of this remarkably brilliant yellow line. It is 587·49 millionths of a millimetre, and is exactly coincident with the line D_3 in the solar chromosphere, attributed to the solar element which has been named *helium*.

Mr. Crookes has kindly consented to make accurate measurements of the position of the lines in this spectrum, which he will publish, and I have placed at his disposal tubes containing the gas. I shall therefore here give only a general account of the appearance of the spectrum.

While the light emitted from a Plücker's tube charged with argon is bright crimson, when a strong current is passed through it, the light from the helium-tube is brilliant golden yellow. With a feeble current the argon-tube shows a blue-violet light, the helium-tube a steely blue, and the yellow line is barely visible in the spectroscope. It appears to require a high temperature therefore to cause it to appear with full brilliancy, and it may be supposed to be part of the high-temperature spectrum of helium.

The following table gives a qualitative comparison of the spectra in the argon[1] and in the helium-tubes.

	Argon-tube.	*Helium-tube.*	
Red ...	1st triplet.	1st triplet.	Equal in intensity.
	2nd pair.	2nd pair.	,, ,,
	Faint line.	Faint line.	,, ,,
	Stronger line.	Stronger line.	,, ,,
	Brilliant line.	Dull line.	Weak in helium.
	Strong line.	Very dim line.	
Red-orange	Moderate Line.	Moderate line.	Equal in intensity.
	,, ,,	,, ,,	,, ,,
	,, ,,	,, ,,	,, ,,
Orange	Faint line.	Faint line.	,, ,,
	Triplet.	Triplet.	,, ,,
Orange-yellow	Pair.	Pair.	,, ,,
			,, ,,
Yellow	Absent.	Brilliant.	W = 587·49 (the helium line, D_3).
Green	7 lines.	7 lines.	Equal in intensity.
Green-blue	5 lines.	5 lines.	,, ,,
	Absent.	Faint.	In helium only.
	Absent.	Brilliant.	,, ,,
Blue...	Absent.	8 lines.	,, ,,
Blue-violet	3 lines, strong.	Barely visible, if indeed present at all.	
	2, fairly strong.	2, fairly strong.	Equal in intensity.
	Absent.	Bright line.	In helium only
	Absent.	4 bright lines.	
Violet	Violet pair.	Violet pair.	Equal in intensity.
	Single line.	Single line.	,, ,,
	Triplet.	Triplet.	,, ,,
	Triplet.	Triplet.	,, ,,
	Pair.	Pair.	,, ,,

It is to be noticed that argon is present in the helium-tube, and by the use of two coils the spectra could be made of equal intensity. But there are sixteen easily visible lines present in the helium-tube only, of which one is the magnificent yellow, *and there are two red lines strong in argon and three violet lines strong in argon, but barely visible and doubtful in the helium-tube.* This would imply that atmospheric argon contains a gas absent from the argon in the helium-tube. It may be that this gas is the cause of the high density of argon, which would place its atomic weight higher than that of potassium.

It is idle to speculate on the properties of helium at such an early stage in the investigation; but I am now preparing fairly large quantities of the mixture, and hope to be able before long to give data respecting the density of the mixture, and to attempt the separation of argon from helium.

[1] Preliminary Note, by Prof. William Ramsay, F.R.S.

[1] The tube then used was the one with which Mr. Crookes' measurements of the argon-spectrum were made. It contains absolutely pure atmospheric argon.

ON THE NEW GAS OBTAINED FROM URANINITE.[1]

ON March 28, Prof. Ramsay was so good as to send me a tube containing a new gas obtained by him from uraninite (cleveite) showing a line in the yellow which was stated to be of the same wave-length as D_3 which I had discovered in 1868. This line Dr. Frankland and myself shortly afterwards suggested might be a line of hydrogen not visible under laboratory conditions, but solar work subsequently showed that this view was untenable, although the gas which produced it was certainly associated with hydrogen.

Subsequently other chromospheric lines were found to vary with the yellow line, and the hypothetical gas which gave rise to them was provisionally named helium, to differentiate it from hydrogen.

It was therefore of great interest to me to learn whether the new gas was veritably that which was responsible for the solar phenomena in question; and I am anxious to tender my best thanks to Prof. Ramsay for sending the tube to enable me to form an opinion on this matter. Unfortunately it had been used before I received it, and the glass was so blackened that the light was invisible in a spectroscope of sufficient dispersion to decide the question.

On March 29, therefore, as Prof. Ramsay was absent from England, in order not to lose time, I determined to see whether the gas which had been obtained by chemical processes would come over by heating in vacuo, after the manner described by me to the Society in 1879, and Mr. L. Fletcher was kind enough to give me some particles of uraninite (Bröggerite) to enable me to make the experiment.

This I did on March 30, and it succeeded; the gas giving the yellow line came over associated with hydrogen in good quantity.

I have since obtained photographs of the gas, both in vacuum tubes while the Sprengel pump has been going; and at atmospheric pressure over mercury. To-day I limit myself to exhibiting two of these photographs.

One of the photographs exhibits a series of spectra taken during the action of the pump. The two lower spectra indicate the introduction of air by a leak, after the capillary had cracked near one of the platinums, giving us on the same plate the banded and line spectrum of air. These prove that there was no air present in the tube when the fourth spectrum was taken. This photograph has not yet been finally reduced, but a preliminary examination has indicated that most of the lines are due to the structure spectrum of hydrogen, but not all of them.

Among the lines which cannot be referred to this origin are two respectively near λ 4471, and λ 4302, which have been observed in the chromosphere, 4471 being as important as D_3 itself from the theoretical point of view to students of solar physics.

Whilst spectrum No. 4 was being photographed with the capillary tube end-on-wise, eye observations were made in another spectroscope directed sideways at it. I give from the Laboratory Note Book the observations I made while photograph No. 4 was being taken, to show that the yellow line was visible during the whole exposure.

Thursday, April 4, 1895. *Plate F. Exposure* 4.

10 minutes exposure.

4.42	Exposure started.
4.43	Yellow line brightening up considerably.
4.44	Suddenly as bright as hydrogen.
4.45	Yellow line double.
4.46	Comparison with D gives yellow line in position of D_3.
4.47	Pump much less full, 7 c.c. of gas collected. Yellow line much brighter.
4.48	Air break introduced. Line still visible, but very faint. Hydrogen lines getting brighter, and some double lines appearing in green.
4-48.5	Air break and jar removed. Yellow line the only one seen, being as bright as C. Line in green the only other line visible.
4.50	Replaced jar. Yellow brightening and the other lines more refrangible, brightening with it.
4.51	Very bright. Steeple nearly full of gas.
4.52	

The lines which appear both in the photographs of the capillary tube and of the gas collected over mercury are as follows. The lines indicated by an asterisk are near lines recorded in the chromosphere by Young or myself, or photographed during the eclipse of 1893:—

Micrometer reading.				Wave-length (Rowland).
3·2495	...	...	...	4581*
·2917	...	...	...	4523*
·2981	...	...	...	4513*
·3234	...	...	...	4479
·3316	...	...	...	4469·5*
·4146	.	...	...	4368
·5740	...	...	...	4196*
·5884	...	...	...	4181
·5933	...	...	..	4177*
·6139	...	...	...	4156*
·6176	...	...	...	4152·5*
·6262	...	...	...	4144*
·6290	...	...	...	4141

With regard to the observations in the visual spectrum, I have not found the uraninite gas to contain the argon lines as given by Mr. Crookes, nor, with the exception of the yellow line, do I get the special lines noted by him in the gas. (Four of these, out of six, seem possibly to be due to nitrogen.)

But I do get lines nearly coinciding with chromospheric lines discovered by me in 1868.

On November 6 of that year I suspected a line less refrangible than C, and so near it that when both were showing brilliantly the pair appeared double, like D in a spectroscope of moderate dispersive power.

Later I discovered another line at 6678·3 (R), which was observed to vary with D_3. There is a line in this position, with the dispersion employed, in the spectrum of the new gas. This line has also been seen by Thalén, as stated by Prof. Cleve in a communication to the Paris Academy (*Comptes rendus*, April 16, p. 835); but the other lines given by him (with the possible exception of the one at 5016), have not been recorded by me.

Although I have at present been unable to make final comparisons with the chromospheric lines, the evidence so far obtained certainly lends great weight to the conclusion that the new gas is one effective in producing some of them, and it is suggested by the photographs that the structure lines of hydrogen may be responsible for others.

I may state, under reserve, that I have already obtained evidence that the method I have indicated may ultimately provide us with other new gases the lines of which are also associated with those of the chromosphere.

Messrs. Fowler, Baxandall, Shackleton and Butler assisted at various times in the investigation.

[1] Preliminary Note, by J. Norman Lockyer, C.B., F.R.S.

NOTES.

WE regret to report that Prof. Huxley is still in a critical state of health. The slight improvement noticed in his condition last week appears not to have been maintained. It is more than eight weeks since his illness began with an attack of influenza, from the effects of which he is now suffering.

M. NORDENSKIÖLD has recently discovered a uranium containing mineral which may prove of great interest at the present time. It forms carbonaceous beds of which the ashes contain two to three per cent. of uranium, and, in addition, traces of nickel and rare earths. This uraniferous material is said to yield a considerable quantity of *nitrogen*.

DR. RICHARD HANITSCH has been appointed Curator of the Raffles Museum at Singapore. Dr. Hanitsch has occupied for some years the post of Demonstrator of Zoology in University College, Liverpool, and is the author of a number of useful papers on the British Sponges.

THE third centenary of Christian Huygens will shortly be reached; for that celebrated Dutch physicist, astronomer, and mathematician died at the Hague on June 8, 1695. His investigations have been reviewed at length in these columns during recent years, and *Die Natur* for April 21 contains a notice concerning them.

THE specimen of the Great Auk, to which we referred in these columns last week, has been sold to the Edinburgh Museum for £350.

DR. GORDON E. MOORE, well-known as a chemist, died at New York on April 16. Prof. Gustav Hirschfeld, a distinguished archæologist, has just died at Wiesbaden. We also notice the death of Prof. K. Thiersch, Professor of Surgery in Leipzig University.

PROF. LLOYD MORGAN will lecture on "Habits of Birds," at the Royal Victoria Hall, Waterloo Bridge Road, on May 7. Other science lectures to be given during this month are: "Electric Tram Cars," by Dr. J. A. Fleming, F.R.S.; "The History of a Myth," by Prof. Sollas, F.R.S.; and "The Life of a Star," by Dr. A. Fison.

GILBERT WHITE's original manuscript of the "Natural History of Selborne," in the form of letters to Thomas Pennant and Daines Barrington, first printed in 1789, was sold by auction last week by Messrs. Sotheby, Wilkinson, and Hodge. The manuscript contains many passages not printed in the several editions of the book, and has never been out of the possession of the lineal descendants of the author. It was bought by Mr. Pearson for £294.

THE *Weekly Weather Report* of April 27 shows that some very heavy falls of rain occurred during the week; in nearly all districts amounts of an inch or upwards were measured, while over the greater part of England the fall was more than double the mean. But the amount of rainfall since the beginning of the year is still below the average, except in the north-east of England. The greatest deficiency is in the west of Scotland, where it amounts to about seven and a half inches.

THE startling advance in market price of petroleum gives interest to the question of exhaustibility of the supply, following close upon the great decrease in supply of natural gas. In the height of the natural gas excitement, the warning of science was too little heeded, and lavish waste hastened the collapse. In 1887 the atmosphere of Pittsburgh was wonderfully clear, owing to the use of this new fuel; but Pittsburgh is again begrimed and sooty.

AT the annual meeting of the National Academy of Sciences, recently held at Washington, Prof. Marsh, who has been president for several terms, was succeeded by Prof. Wolcott Gibbs, of Cambridge, who was elected for the ensuing term of six years, while Prof. Asaph Hall was re-elected home secretary. Prof. Alexander Agassiz is foreign secretary, and the members of the Council elected are Profs. George J. Brush, Othniel C. Marsh, Benjamin A. Gould, George H. Goodale, Simon Newcomb, and Ira Remsen.

A THREE days' conference on sanitary progress and reform was held at Manchester last week. A meeting introductory to the conference was held in the museum of Owens College, at which Prof. Boyd Dawkins delivered an address on prehistoric traces of sanitation. At the annual meeting of the Manchester and Salford Sanitary Association, in connection with which the conference was held, it was resolved that a Smoke Abatement League should be formed. Sir H. Roscoe, who afterwards took the chair at the conference session, pointed out that though attention was paid to the smoke from factory chimneys and from manufacturing operations, the larger question of the smoke from ordinary household fires was often neglected.

A VERY serious disaster is reported from France. A dam holding in check an immense reservoir of the Eastern Canal at Bousey, near Epinal, broke down on Saturday morning for a distance of some 300 feet. The torrent of water thus set free swept through Bousey, Avière, Uxegney, and Sanchey, carrying all before it, and washed away portions of the railway lines of Jussey and Nancy. Many bridges were carried away, and a great number of people were drowned. The Bousey reservoir (says the Paris correspondent of the *Times*) contained seven million cubic metres of water. The dam, which was constructed between 1879 and 1884, and was strengthened in 1888–89, was 60 feet thick at the base, and the foundation is laid in sandstone. According to a report sent out by the Minister of Public Works, there have never been any signs of weakness in the structure. Attempts are being made to throw the responsibility for the accident upon the engineers who superintended the strengthening of the dam six years ago.

A NUMBER of interesting objects obtained during the excavations of the Roman city at Silchester are on view at the Society of Antiquaries. During the past five years, the excavations have been carried on by Messrs. St. John Hope, Fox, Jones, and Stephenson, and some very valuable results were obtained last year. Twelve rectangular enclosures or buildings were found, all of the same type, and containing furnaces obviously of an industrial character and of various sizes, some of them being circular and others oblong. It is believed that these buildings and their adjuncts were devoted to the dyeing industry, and this conjecture is made probable by the large number of wells discovered, one of which was of peculiar and unusual construction. The circular furnaces correspond exactly with a dyeing furnace at Pompeii. They were, there is every reason to believe, used for dyeing. But there are a number of other furnaces with a straight flue, which are supposed to have been intended for drying. There are also traceable several rooms which, it is presumed, were intended for the storage of goods and materials, and open spaces with no remains of flues which may have been used for bleaching grounds. A number of querns for hand-grinding the madder-roots used for dyeing purposes have also been discovered.

THE sixty-sixth anniversary meeting of the Zoological Society was held on Tuesday, with the President, Sir William H. Flower, K.C.B., F.R.S., in the chair. Dr. P. L. Sclater, F.R.S., read the report of the Council, in which it was announced that the silver medal of the Society had been awarded to Mr. Henry H. Johnston, C.B., H.M. Commissioner for British Central Africa, for his distinguished services to all branches of natural history by his collections made in Nyasaland, which had been described in the Society's *Proceedings*. The total receipts of the Society for 1894 amounted to £25,107 0*s*. 7*d*. The number of visitors to the Gardens during the year was 625,538, the corresponding number in 1893 having been 662,649; the decrease in the number of entrances (37,111) being due to the unfavourable weather of 1894. The number of animals in the Society's collection on December 31 last was 2563, of which 669 were mammals, 1427 birds, and 467 reptiles. Amongst the additions made during the past year, eleven were specially commented upon as of remarkable interest, and in most cases representing species new to the Society's collection. Among these were two remarkably fine specimens of the Hamadryad snake, a young white-tailed gnu (born in the Gardens), an eland of the striped form from the Transvaal (obtained by purchase), two giant tortoises, a young male Pleasant antelope, 2 Somali ostriches of the blue-skinned variety, 10 Surinam water-toads, a Pel's owl, and 2 tree kangaroos. About 30 species of mammals, 12 of birds, and 1 of reptiles had bred in the Society's Gardens during the summer of 1894. The Right Hon. George Denman, F. Du Cane Godman, F.R.S., Sir Hugh Low, G.C.M.G., Dr. St. George Mivart, F.R.S., and Osbert Salvin, F.R.S., were elected into the Council in the place of the retiring members, and Sir William H. Flower was re-elected President,

Charles Drummond, Treasurer, and Dr. Sclater, Secretary, to the Society for the ensuing year.

THE first of the two conversaziones held at the Royal Society every year, takes place as we go to press. Annual receptions and exhibits, conducted upon much the same lines, are gradually being instituted by learned societies in various parts of the world. The New York Academy of Sciences recently held a similar exhibition, at which five hundred different objects of scientific interest were shown. From a report in the *Scientific American*, it appears that many of the exhibits were of a very striking character. A number of photographs of comets, of the Milky Way, and of star spectra, were shown by Profs. Barnard and Keeler, of the Lick and Allegheny Observatories. One of the most novel exhibits in physics, was a series of Chladni figures, shown by Prof. Alfred M. Mayer. The figures were formed in white sand upon vibrating metallic plates. Prof. Mayer's process consisted in fixing the sand upon a black background after the figures had been formed, by means of a fixative spray. These plates demonstrated the truth of Lord Rayleigh's theoretical deductions, and differed radically from all figures which are shown in text-books in the fact that none of the lines intersect. The physical exhibit was an extensive one, including a large number of instruments for spectroscopic, as well as for sound and light, measurements. The mineralogical exhibit included about one hundred objects. Biology was represented by preparations of nerve cells from the brain and spinal cord, by Prof. Golgi's method; and there were also shown several series of similar pictures bearing upon problems of inheritance, both in animals and plants. Bacteriology, mechanics, physiology, experimental psychology, anatomy, geology, and palæontology all took part in the exhibition. In vertebrate palæontology, the main exhibit was that showing the evolution of the horse. The series connecting the oldest known horse of the Lower Eocene period with the modern horse was probably the most complete which has ever been brought together. The little four-toed horse, recently acquired by the American Museum of Natural History from the collection of Prof. Cope, of Philadelphia, was exhibited. Although fully matured, it is only 3½ hands high. The skull and limbs, nevertheless, display the characteristics of the horse. The teeth are short and simple; the limbs are scarcely larger in diameter than a good-sized pencil, and there are four toes, all resting upon the ground, in the fore-foot. A remarkable series of feet was also exhibited, giving all the stages between this four-toed horse and the modern one-toed animal. The reception at which the exhibits were shown was so successful that it has been decided to hold a similar one every year.

DR. BERTRAM WINDLE contributes a paper to the *Journal of Anatomy and Physiology*, "On the effects of Electricity and Magnetism on development." The observations recorded were made on developing silkworms, trout, and chick embryos. In the case of the chick, the number of abnormally developed embryos was much greater in eggs incubated around the poles of a strong magnet than usual. With one exception all the malformations were associated with deficient development of the vascular area. Dr. Windle has not conclusively shown that this large proportion of abnormal embryos was actually due to the presence of the magnet, yet his results on the whole agree with those of Maggiorani, although certain points of difference were observed in the defective embryos. The eggs of the silkworm moth were found to develop quite normally in a strong magnetic field. An electric current passing through a tank in which trout ova had been placed, seemed to produce an arrest of development. Dr. Windle concludes from his own observations and those of other authors, "that electricity produces an arresting effect upon development," while it is "very doubtful whether a magnetic field has any definite effect upon development or not."

A RECENT number of *Comptes rendus* contains an interesting paper by M. Branly, on the rate of loss of an electric charge due to the effect of light in the case of badly-conducting bodies. When the source of illumination is a body heated to a dull red, it is the condition of the illuminating surface which plays the chief part in the phenomenon. The nature of the charged body seems to have no effect. In the case where the illumination is rich in highly refrangible rays, however, the case is quite different, and the chief results obtained are as follows:—A disc of wood or marble, polished or unpolished, shows a marked loss of electricity when illuminated. If the disc is negatively electrified, the loss is more rapid than if it is positively electrified; but the difference is very much less marked than is the case with metal discs, particularly if they are polished. Similar results are obtained with cardboard, terra-cotta, and glass heated to 100°. The loss of a positive charge is rapid, while that of a negative one is slow in the case of varnished wood, or wood coated with a thin layer of oil, paraffin or tallow. With a metal disc coated with tallow, the loss when negatively electrified is slow, while the loss when positively electrified is very rapid. If a disc of polished wood, in which the loss of a negative charge is more rapid than that of a positive one, though the difference is not very marked, has the surface covered with a thin coating of plumbago, the loss with a negative charge becomes much more rapid than with a positive one. A metal plate covered with grease only loses a negative charge very slowly, the rate of loss of a positive charge being rapid. If, however, a thin coating of copper filings is spread over the tallow by means of a sieve, the loss with a positive charge becomes much more rapid than with a negative one. If powdered aluminium is used in the place of copper, the rates of loss in the case of positive and negative charges become nearly equal.

THE United States Department of Agriculture publishes, in *Bulletin* No. 6 of the Department of Vegetable Pathology, a detailed paper, by Mr. D. G. Fairchild, on the use of "Bordeaux Mixture," a preparation of copper sulphate and lime, as a fungicide; and the mode of treatment of a number of diseases of fruit-trees, corn-crops, and garden plants caused by fungi.

THE ninth edition has just been issued of part I of the *London Catalogue of British Plants*, comprising the Phanerogamia, Filices, Equisetaceæ, Selaginellaceæ, Marsileaceæ, and Characeæ. The changes introduced in this edition represent the results of the field-work, the critical study of British plants, and the researches on nomenclature, made during the last nine years. It is now edited by Mr. F. J. Hanbury.

THE part of the *Agricultural Gazette of New South Wales* for January 1895 is chiefly occupied by papers on practical agriculture and breeding. Four species of so-called mahoganies of New South Wales are described by Mr. J. H. Maiden, all species of *Eucalyptus*. The life-history of the *Phylloxera vastatrix*, and the injuries inflicted by it on the vine, are described at length by Mr. J. A. Despeissis, and are illustrated by a coloured plate and numerous woodcuts.

WITH the title *Allgemeine botanische Zeitschrift für Systematik, Floristik, und Pflanzengeographie*, a new monthly botanical journal has been started at Carlsruhe, under the editorship of Herr A. Kneucker. Its aim is especially to deal with the study of difficult groups of plants, diagnoses of species, critical forms and hybrids, geographical botany, and the results of the travels of botanists.

IN the *Bulletin* No. 9 of the *Minnesota Botanical Studies* is an interesting article by Mr. A. P. Anderson, on the Grand Period of Growth in the Fruit of *Cucurbita pepo*. From the time of fertilisation to that of ripening, the development may be divided into three periods—a period of active and continuous increase

from the time of pollination to the grand maximum; one of decline in the daily increase and rise in the daily decrease from the grand maximum to the beginning of ripening; and the ripening period. During this latter period an extended decrease, due to transpiration, lasting throughout the daily hours, was quickly followed by the maximum increase. At the time of the grand maximum the fruit gained 782 grammes in weight during twenty-four hours. The variations in length of the internodes occurred simultaneously with corresponding increase and decrease in the weight of the fruit.

THE Natural History Museum acquired last year some very remarkable corals, the largest weighing as much as fifteen hundred pounds. Two of these specimens have furnished Prof. Jeffrey Bell with subject for a note "On the variations observed in large Masses of *Turbinaria*," in the April *Journal* of the Royal Microscopical Society. The note is accompanied by two plates reproduced from photographs, and the point to which it directs attention is the considerable difference in size and form of the calicles in different portions of the same mass of coral. The plates show totally distinct forms comparatively close to one another, though the large mass, of which they represent parts, may be taken to be formed by a single species—*Turbinaria mesenterina*. The variability may, Prof. Bell points out, partly account for the difficulty which all students of corals have in determining specimens of the genus *Turbinaria*.

A YEAR ago the Board of Trinity College, Dublin, deposited in the Dublin Science and Art Museum the collection of weapons, &c., chiefly from the South Sea Islands, in their possession. A catalogue of the collection has now been prepared and published, with an introduction by Dr. V. Ball, the Director of the Museum. The collection has been known by common tradition as the "Cook Collection"; but a careful search has failed to bring to light direct evidence that the objects were really sent home by Captain Cook, though some of them are identical with objects figured in "Cook's Voyages." There is little doubt, however, about the reality of the association of the objects with the voyage, for the Minutes of the Board of Trinity College record that they were presented to the College in 1777 by Dr. Patten, who has been identified as the surgeon of the *Resolution* during Cook's second voyage. Part of the collection appears to have reached the College through the relatives of Captain King, who brought home the *Resolution* and *Discovery* after Captain Cook had been murdered. A brief statement as to other museums where collections of Cook's weapons are preserved, is given by Dr. Ball in the introduction to the catalogue. It is stated that in Great Britain the British Museum collection is the best in the world. Next to it in importance, in England, comes the collection in the Pitt-Rivers Museum. The Hunterian Museum in Glasgow University also contains some specimens, but how many is uncertain. So far as Dr. Ball has been able to ascertain, the museums on the continent which possess Cook collections are, arranged alphabetically, at Berne, Florence, Göttingen, Lausanne, Munich, Stockholm, and Vienna.

MESSRS. WILLIAM WESLEY AND SON have issued a very full catalogue of works on geology, offered for sale by them. The catalogue contains classified titles of more than two thousand different volumes, memoirs, and separate papers of interest to geologists. R. Friedländer and Söhn, Berlin, have sent us Nos. 1-5 of this year's *Naturæ Novitates*. Bibliographers well know that the lists form a good index to current scientific literature. We have also received a catalogue, from Felix L. Dames, Berlin, containing titles of works on the invertebrates.

THE additions to the Zoological Society's Gardens during the past week include a Rhesus Monkey (*Macacus rhesus*, ♀) from India, presented by Mr. Julius Scovell; a Pig-tailed Monkey (*Macacus nemestrinus*, ♀) from Sumatra, presented by Mr. D. Orville B. Dawson; three Maholi Galagos (*Galago maholi*) from South Africa, presented by Miss Van Beren; a Crowned Hawk Eagle (*Spizaetus coronatus*) from South Africa, presented by Dr. Schinland; an Antipodes Island Parrakeet (*Cyanorhamphus unicolor*) from Antipodes Island, New Zealand, presented by Sir Walter L. Buller; a Leopard Tortoise (*Testudo pardalis*), a Cape Viper (*Causus rhombeatus*) from South Africa, presented by Mr. J. E. Matcham; three Green Lizards (*Lacerta viridis*) from Jersey, presented by Masters J. S. and A. H. Hills; a Common Viper (*Vipera berus*) from Hampshire, presented by Mrs. P. C. Mitchell; two Angora Goats (*Capra hircus*, var.), born in the Gardens.

OUR ASTRONOMICAL COLUMN.

SATURN'S RINGS.—In a recent communication to the Royal Astronomical Society, Prof. Barnard states that his measurements of the rings of Saturn show that no changes have taken place since the first systematic measures were made, and that there is no ground for the supposition that the rings are closing in upon the planet.

SEARCH EPHEMERIS FOR COMET 1884 II.—Dr. Berberich gives the following search ephemeris for Barnard's periodic comet of 1884 (*Ast. Nach.* 3260):

		R. A. h.	m.	s.	Decl.	
May	2	22	5	36	−18	24
	10		35	16	15	38
	18	23	3	54	12	40
	26		31	20	9	35
June	3		57	26	6	27
	11	0	22	7	3	22
	19		45	20	−0	24
	27	1	6	59	+2	25

The positions are for Berlin midnight, and the probable error amounts to 20m. in R.A. and 3° in decl. The comet passes from Aquarius to Cetus early in June, and remains in that constellation throughout the month. It must be looked for before sunrise.

THE HAMBURG OBSERVATORY.—From the report of the Hamburg Municipal Observatory we learn that the chief astronomical researches during 1894 had to do with the movements of comets and minor planets, and with the changes in variable stars of long period. Two memoirs of some importance have also been published (*Mitt. der Hamburger Sternwarte*, Nos. 1 and 2, 1895). The first of these is a catalogue of the positions of 105 nebulæ and star-clusters, reduced from observations made in the period 1871–1880, by Dr. Pechüle and the present director, Prof. G. Rümker. The positions have been deduced from micrometric measures in relation to known comparison stars, and are tabulated for the epoch 1875. Comparisons are made with the results of other observers, and, considering the difficulties attending the observations, there is a good all-round accordance of results; but it seems yet too early to expect much information with regard to proper motions. The second memoir is an investigation by Dr. Carl Stechert of the orbit of the minor planet Tycho (258) and of the perturbations produced by Jupiter and Saturn. It is shown that the probable apparent semi-diameter of the planet at opposition is about 0″·05, the true semi-diameter being something between 50 and 80 kilometres. An ephemeris is given for observations during the opposition of June 20, 1895.

THE LATE M. TROUVELOT.—By the death of M. L. Trouvelot, on April 22, observational astronomy has lost one of its foremost workers. M. Trouvelot was born at Guyencourt, in 1827, and after the *coup d'état*, he went to Cambridge, U.S.A., where he lived until 1882. His first published works, which appeared in 1866, were on natural history subjects; later he became an astronomer at the Harvard College Observatory, and commenced the observations of the sun and planets which have made his name known to all students of celestial science. Shortly after the Meudon Observatory was founded, he returned to France, and has since then carried on his work in it. Trouvelot's important observations of the planet Venus, published in 1892, are still fresh in the minds of astronomers. He also paid attention to the planets Jupiter and Saturn. His beautiful drawings of celestial objects and phenomena observed by him are to be found in many works on astronomy.

THE SUN'S PLACE IN NATURE.[1]

V.

AT the end of the last lecture we arrived at that point of our inquiry which is connected with the possible first stage of all cosmical bodies, and we saw that there was a considerable amount of evidence in favour of the idea that in this first stage all cosmical bodies are not masses of hot gas, but that their temperature is low.

Continuing this inquiry in the light of the suggestion that the first stage might be connected with swarms of meteorites, we found the great probability that, in swarms or streams of meteorites, or meteoritic dust, we had to deal with the rea basis of all cosmical bodies.

Now, if we take the heavens as we find them, whether we deal with stars, secondary bodies, or satellites, we find that they are all in movement, and it therefore follows that in these

FIG. 22.—The Great Nebula in Andromeda, from a photograph by Dr. Roberts.

earliest stages with which we have now to deal, whether they were meteoritic swarms or streams, they were also in movement. I have already taken an opportunity of pointing out to you how very important these considerations are when we come to inquire into the constitution of each nebula. I showed you in the last lecture a beautiful photograph (Fig. 7, vol. li. p. 397), taken by Dr. Roberts, of the spiral nebula in one of our northern constellations, and I now propose to show you another very similar to it, in order, if I can, to bring more closely before you certain of the facts which were then indicated. In this wonderful photograph of the nebula in Andromeda we are undoubtedly dealing with streams, and the movements towards the centre are all along spirals. In the case of the other nebula we were in a better condition for observing the actual direction of motion because we were looking down on the system, we got a section in the plane of movement; but we are looking at this nebula in an inclined direction, though I think you will still have no difficulty in seeing that the various streams round the centre of condensation are all of them of a spiral form, with certain condensations interspersed here and there along them.

We have a condensation in the prolongation of one of the spirals, and there is considerable clustering of apparent stars along those lines, which I ventured in my last lecture to call stream lines, for the reason that I was anxious to indicate that we had in these appearances, not signs which told us of the existence of matter—so that when you have not the appearances you would be justified in supposing that there was no matter—but an indication of movement in matter, so that we may imagine that this nebula and others like it do probably consist of a swarm of meteorites, extending enormously in pace beyond the indications which you see, for the reason that towards the centre the movements will be more violent than they are towards the outside. We are there face to face with the idea that we have to deal with orderly movements of meteoritic masses. Now, let me call your attention to this fact. If the movements are orderly, it means that the movements of the constituent particles of the swarm, all of them, or most of them, will be in the same direction; that in that case you have the condition of minimum disturbance, and therefore the condition of minimum temperature.

We can pass from such a nebula as this to the well-known planetary nebulæ. Almost all the knowledge which we have of these nebulæ we owe to the labours of Sir William and Sir John Herschel. You will see that so far as appearance goes, we have in these planetary nebulæ almost to deal with a planet like Jupiter, except that we do not see the belts. That is why these bodies are called planetary nebulæ; they give us the idea that we are dealing with discs. If we pass for a moment from a nebula whch is simply discoidal to one such as is represented in another part of the diagram, you find there that we get a very faint disc, including much brighter condensation at the centre. If you look at the others, you will find that we get a very obvious condensation towards the centre; there is a very considerable difference in the intensity of the light given out as the centre is approached.

Of course we understand that if in these, also, the movements are quite orderly, we must not expect to get any very great disturbance, and therefore—if these disturbances produce high temperatures—we shall not expect to get indications of any particularly high temperatures from their external portions.

Dealing with nebulæ, then, as a whole, it does not seem too much to say that we are justified in supposing that they may advance towards condensation along two perfectly distinct roads. If we consider a regular spiral nebula, like the one in Andromeda, or a planetary nebula, we may imagine them living their life as nebulæ without very much disturbance; there is not much fighting to be done, they progress in orderly fashion towards the condition of complete condensation at the centre.

But there is another way.

In the nebula of Orion we get absolute absence of anything like regularity. In any part where the structure can be studied, we find it consists of whirls and streams crossing each other, some of them straight, some of them curved, the whole thing an irregular complicated mixture of divergent movements, so far as the photographs, which are absolutely untouched, can give us any idea of what is going on. Take, for instance, the magnificent streamer trending upwards. It gradually becomes brighter until it reaches one of the brightest parts of the nebula; and observe, also, the stars which seem dotted over it as on a shield. It is quite obvious that we cannot, in such a structure as that, expect to get the same conditions that we met with in the nebula of Andromeda, and in the planetary nebulæ. And, in fact, we do not. In this nebula, which speaks of disturbance in every inch of it, we have spectroscopic indications of very high temperature indeed. Carbon is replaced by hydrogen. In such a nebula as this, it is impossible for us to pick out the place of condensation; the condensation may be held to be anywhere, for disturbances are obviously everywhere. And you remember, I hope, that I pointed out to you that the part of

[1] Revised from shorthand notes of a course of Lectures to Working Men at the Museum of Practical Geology during November and December, 1894. (Continued from vol. li. page 592.)

the nebula ordinarily seen is but the brightest part of a nebula extending over a space in the surrounding neighbourhood, which recent research shows is scarcely limited to the whole constellation.

Now, it so happens that the spectrum of the nebula of Orion has recently been very carefully studied from the point of view of the chemical substances which may be building up this special spectroscopic type. Here is a photograph of a part of the spectrum of the nebula of Orion; and I may tell you that it is a very difficult thing to obtain a photograph of such a very feeble light source. It is a copy of a photograph which was exposed for something like three hours at the focus of a 30-inch mirror of short focus; and in copying it we lose a great deal of the detail, a great many of the lines which are recorded by Dame Nature herself in what we call the negative. The negative

FIG. 23.—The Great Nebula in Orion, from a long exposure photograph by Dr. Roberts.

contains something like fifty lines, which have already been measured; but in the attempt to enlarge, a great many of these have been left behind.

You will see, however, without any difficulty, that the spectrum shows many bright lines; that being so, an attempt has been made to determine the positions of all of them. The result is really extremely interesting. We find, in fact, that there may in all probability be three perfectly different sources of the bright lines which, taken together, build up the so-called spectrum of the nebula. In the first place, I showed you that when we experiment with meteoritic dust in our laboratories, it has not been subjected to a low pressure very long before it begins to give out certain compounds of carbon, mingled with hydrogen gas, and we find that in the nebula of Orion we really do get indications of gaseous compounds of carbon, and also of the gas hydrogen. In order to make the distinction perfectly clear between the two other possible sources of nebula lines, let me ask you for one moment to conceive yourselves in the middle of the gigantic battle which is going on between meteoritic particles in such a nebula as that of Orion. You have particles rushing together in all possible directions, particles, no doubt, different in origin. You will expect, among those millions and billions and trillions of collisions, to get a very considerable number of grazes; and the whole point of collisions among physical particles is that, if two things go straight at each other, you get what you may call an end-on collision, which may be bad for one or both of the bodies concerned; physically we may say the temperature under these circumstances is at a maximum. But you will understand that the number of grazes, or near misses, must be very much greater than the number of end-on collisions; in such a case as we are imagining, there will be an immense number of grazes. What will a graze do? It is simply a slight collision; the amount of temperature developed by it will be small; we shall therefore get the production of vapours at a low temperature, and if we get any luminous effect at all, it will be one proper to the vapours at low temperature. So that on first principles we should expect in such a nebula as the one we are discussing to get a very large number of grazes, giving us low temperature effects, and a very much smaller number of end-on collisions, giving us very high temperature effects. Now, what are the facts? We say the most numerous collisions are partial ones, grazes. Well, there is the fluting, most probably due to magnesium at λ500, and that fluting of magnesium is the lowest temperature indication of the existence of magnesium; if magnesium becomes luminous at all by virtue of its temperature, one of the first things revealed to us spectroscopically is the particular fluting in question. We may also note the longest lines seen in the oxy-hydrogen flame of iron, calcium and magnesium as well. Those lines we are justified in considering as indications of an enormous number of grazes among these meteoritic particles. But that is not all. Going further, we find that there will be a small number of end-on collisions giving us the highest possible temperature. Being students of science, we are of course anxious to know what conditions are present in a case of that kind; that is, we want to know what the possible results of the highest temperature will be. The natural thing, I think, is to go to the sun, which is pretty hot, and then find out the very hottest place, which we can do by means of our spectroscopes, and then study very carefully, for years even, the spectroscopic indications in that particularly hottest place of the nearest star which we can get at. I hope you will acknowledge that that is a philosophic way of going to work. Thus we are landed in what is called the chromosphere of the sun. The upper atmosphere of the sun must be rapidly cooling, but the chromosphere is a thin envelope some 5000 or 10,000 miles thick, just outside the photosphere, agreed to be the hottest part of the sun within our ken, and therefore any lines which we see special to that region are called chromospheric lines, and they should be proper to high temperatures.

The chromospheric line D_3 represents a line near the sodium line D in the solar spectrum, which with a few others has the proud pre-eminence of nearly always being bright; hence we suppose that we have something hotter than anything else which exists at the exterior level of the solar photosphere. Running in couples with this line D_3 there is another in the blue part of the spectrum, represented by a certain wave-length (4471) which behaves always in the same way, *i.e.* it is almost always seen very bright, and it is never seen dark among the Fraunhofer lines in the solar spectrum. From the solar point of view then, as the sun is a thing that we can get at better than any of the other stars, because it is so near to us, a mere trifle of 90 millions of miles or so, we are justified in saying that these two lines represent, in fact, the spectrum of the hottest part of space about which we can be absolutely certain. Hence it is very interesting to inquire whether or not these two lines exist in the nebulæ as representing the high temperature results of end-on collisions.

They do exist in nebulæ, and in some of them they are among the most striking indications in the spectrum.

So that we find in the spectrum of the nebula of Orion, when it is carefully studied, indications of the gases which are known to be occluded in meteorites, and which are perfectly prepared to come out of them the moment you give them the least

chance. Then, also, there is the indication of the results of an infinitely great number of grazes in the shape of lines of metals which we see at the temperature of the oxy-hydrogen flame, but which we do not see so well at the temperature of the arc and the spark; and, on the other hand, there are indications of the results of high temperature which we can study in the sun, and such obvious indications of high temperature that we get the two lines which I have referred to, neither of which has ever been seen so far in any terrestrial laboratory, although they are very familiar indeed to students of solar physics.

The total result of all this inquiry has been that the mean temperature of the meteoritic phenomena brought before us by the nebula of Orion is distinctly low. That is a result of extreme interest and importance, because, remembering what was said about the objection to Laplace's view of high temperature gas because it violated the laws of thermodynamics, we have now, after minute study, come to a conclusion regarding the structure of these nebulæ, which is quite in harmony with the laws of thermodynamics.

When the series of lines associated with high temperatures was first recorded in the spectrum of the nebulæ, I stated that possibly this might be due to the fact that in regions of space where the pressure always operative is extremely low, we might be in the presence of chemical forms which are unfamiliar to us here, because all that we know of here chemically is the result probably of considerable temperature, and not very low pressure. It was therefore supposed that these lines might represent to us the action of unfamiliar conditions in space. Thus, if we have a compound chemical substance, and increase its temperature sufficiently, the thing goes to pieces—is dissociated; but imagine a condition of things in which we have that same chemical substance for a long time exposed to the lowest possible pressure. Is it possible that that substance will ever get pulled to bits? If so, we may imagine parts of space which will contain these substances pulled to bits which really constitute finer forms of matter than our chemical substances. So that we may logically expect to get the finest possible molecules as distinct entities in the regions where the pressure is the lowest possible. These forms are, of course, those we should expect to be produced by a very high temperature brought on by end-on collisions; hence the line of thought is not greatly changed in both these explanations, and I think that probably future research may show that we are justified in looking to both of these possible causes as those which produce for us those so-called "chromospheric lines" which we find in the spectrum of the nebulæ.

However that may be, we have arrived finally at the conclusion that the temperature of these nebulæ is low on the meteoritic hypothesis.

I have already referred in my previous lectures to Dr. Huggins's views connected with the nebulæ and stars, and you will therefore quite understand that I am delighted to find that Dr. Huggins has now come to the conclusion that in nebulæ we have distinctly a relatively low temperature. In 1889 Mr. Huggins wrote:[1] "They [the nebulæ] consist probably of gas at a high temperature," but in the address of 1891, to which I have already had occasion to refer, he gives this view up, and refers to "the much lower mean temperature of the gaseous mass *which we should expect at so early a stage of condensation*" !![2]

I am also glad to say that Dr. Keeler is also perfectly prepared to accept the view I have been insisting on. So that, if the opinion of astronomers of repute is worth anything, we do seem to have arrived at very solid ground indeed on this point, so far as a consensus of opinion can make any ground solid.

J. NORMAN LOCKYER.

(*To be continued.*)

THE RARER METALS AND THEIR ALLOYS.[3]

THE study of metals possesses an irresistible charm for us, quite apart from its vast national importance. How many of us made our first scientific experiment by watching the melting of lead, little thinking that we should hardly have done a bad life's work if the experiment had been our last, provided we had only understood its full significance. How few of us forget that we wistfully observed at an early age the melting in an ordinary fire of some metallic toy of our childhood; and the experiment has, like the "Flat iron for a farthing," in Mrs. Ewing's charming story, taken a prominent place in literature which claims to be written for children. Hans Andersen's fairy tale, for instance, the "History of a Tin Soldier," has been read by children of all ages and of most nations. The romantic incidents of the soldier's eventful career need not be dwelt upon; but I may remind you that at its end he perished in the flames of an ordinary fire, and all that could subsequently be found of him was a small heart-shaped mass. There is no reason to doubt the perfect accuracy of the story recorded by Andersen, who at least knew the facts, though his statement is made in popular language. No analysis is given of the tin soldier; in a fairy tale it would have been out of place, but the latest stage of his evolution is described, and the record is sufficient to enable us to form the opinion that he was composed of both tin and lead, certain alloys of which metals will burn to ashes like tinder. His uniform was doubtless richly ornamented with gold lace. Some small amount of one of the rarer metals had probably—for on this point the history is silent—found its way into his constitution, and by uniting with the gold, formed the heart-shaped mass which the fire would not melt, as its temperature could not have exceeded 1000°; for we are told that the golden rose, worn by the *artiste* who shared the soldier's fate, was also found unmelted. The main point is, however, that the presence of one of the rarer metals must have endued the soldier with his singular endurance, and in the end left an incorruptible record of him.

This has been taken as the starting-point of the lecture, because we shall see that the ordinary metals so often owe remarkable qualities to the presence of a rarer metal which fits them for special work.

This early love of metals is implanted in us as part of our "unsquandered heritage of sentiments and ideals which has come down to us from other ages," and future generations of children will know far more than we did; for the attempt will be made to teach them that even psychology is a branch of molecular physics, and they will therefore see far more in the melted toy than a shapeless mass of tin and lead. It is really not an inert thing; for some time after it was newly cast, it was the scene of intense molecular activity. It probably is never molecularly quiescent, and a slight elevation of temperature will excite in it rapid atomic movement anew. The nature of such movement I have indicated on previous occasions when, as now, I have tried to interest you in certain properties of metals and alloys.

This evening I appeal incidentally to higher feelings than interest, by bringing before you certain phases in the life-history of metals which may lead you to a generous appreciation of the many excellent qualities they possess.

Metals have been sadly misunderstood. In the belief that animate beings are more interesting, experimenters have neglected metals, while no form of matter in which life can be recognised is too humble to receive encouragement. Thus it happens that bacteria, with repulsive attributes and criminal instincts, are petted and watched with solicitude, and comprehensive schemes are submitted to the Royal Society for their development, culture, and even for their "education,"[1] which may, it is true, ultimately make them useful metallurgical agents, as certain micro-organisms have already proved their ability to produce arseniuretted hydrogen from oxide of arsenic.[2]

It will not be difficult to show that methods which have proved so fruitful in results when applied to the study of living things, are singularly applicable to metals and alloys, which really present close analogies to living organisms. This must be a new view to many, and it may be said, "it is well-known that uneducated races tend to personify or animate external nature," and you may think it strange that the attempt should be made to trace analogies which must appear to be remote, between moving organisms and inert alloys, but "the greater the number of attributes that attach to anything, the more real that thing is."[3] Many of the less known metals are very real to me, and I want them to be so to you; listen to me, then, as speaking for my silent metallic friends, while I try to secure for them your sympathy and esteem.

First, as regards their origin and early history. I fully

1 *P.R.S.* vol. xlvi. p. 59.
2 In this printing of the passage, the italics and notes of exclamation are mine.—J. N. L.
3 A Friday evening discourse, delivered at the Royal Institution on March 15, by Prof. Roberts-Austen, C.B., F.R.S.

1 Dr. Percy Frankland specially refers to the "education" of bacilli for adapting them to altered conditions. *Roy. Soc. Proc.*, vol. lvi., 1894, p. 539.
2 Dr. Brauner. *Chem. News*, Feb. 15, 1895. P. 79.
3 Lotze, "Metaphysic," § 49, quoted by Illingworth. "Personality, Human and Divine." Bampton Lectures, 1894, p. 43.

share Mr. Lockyer's belief as to their origin, and think that a future generation will speak of the evolution of metals as we now do of that of animals, and that observers will naturally turn to the sun as the field in which this evolution can best be studied.

To the alchemists metals were very living indeed; they treated them as if they were, and had an elaborate pharmacopœia of "medicines" which they freely administered to metals in the hope of perfecting their constitution. If the alchemists constantly draw parallels between living things and metals, it is not because they were ignorant, but because they recognised in metals the possession of attributes which closely resemble those of organisms. "The first alchemists were gnostics, and the old beliefs of Egypt blended with those of Chaldea in the second and third centuries. The old metals of the Egyptians represented men, and this is probably the origin of the *homunculus* of the middle ages, the notion of the creative power of metals and that of life being confounded in the same symbol."[1]

Thus Albertus Magnus traces the influence of congenital defects in the generation of metals and of animals, and Basil Valentine symbolises the loss of metalline character, which we now know is due to oxidation, to the escape from the metal of an indestructible spirit which flies away and becomes a soul. On the other hand, the "reduction" of metals from their oxides was supposed to give the metals a new existence. A poem[2] of the thirteenth century well embodies this belief in the analogies between men and metals, in the quaint lines :—

"Homs ont l'estre comme metaulx,
Vie et augment des vegetaulx,
Instinct et sens comme les bruts,
Esprit comme ange en attributes."

"Men have being"—constitution—like metals; you see how closely metals and life were connected in the minds of the alchemists.

"Who said these old renowns, dead long ago, could make me forget the living world?" are words which Browning places in the lips of Paracelsus, and we metallurgists are not likely to forget the living world; we borrow its definitions, and apply them to our metals. Thus nobility in metals as in men, means freedom from liability to tarnish, and we know that the rarer metals, like the rarer virtues, have singular power in enduing their more ordinary associates with firmness, elasticity, strength, and endurance. On the other hand, some of the less known metals appear to be mere "things" which do not exist for themselves, but only for the sake of other metals to which they can be united. This may, however, only seem to be the case because we as yet know so little about them. The question naturally arises, how can the analogies between organic and inorganic bodies be traced? I agree with my colleague at the École des Mines of Paris, Prof. Urbain le Verrier, in thinking that it is possible[3] to study the biology, the anatomy, and even the pathology of metals.

The anatomy of metals—that is, their structure and framework—is best examined by the aid of the microscope, but the method of autographic pyrometry, which I brought before you in a Friday evening lecture delivered in 1891, is rendering admirable service in enabling both the biology and pathology of metals to be studied, for, just as in biological and pathological phenomena vital functions and changes of tissue are accompanied by a rise or fall in temperature, so molecular changes in metals are attended with an evolution or absorption of heat. With the aid of the recording pyrometer we now "take the temperature" of a mass of metal or alloy in which molecular disturbance is suspected to lurk, as surely as a doctor does that of a patient in whom febrile symptoms are manifest.

It has, moreover, long been known that we can submit a metal or an alloy in its normal state to severe stress, record its power of endurance, and then, by allowing it to recover from fatigue, enable it to regain some, at least, of its original strength. The human analogies of metals are really very close indeed, for, as is the case with our own mental efforts, the internal molecular work which is done in metals often strengthens and invigorates them. Certain metals have a double existence, and, according to circumstances, their behaviour may be absolutely harmful or entirely beneficial.

[1] Berthelot, *Les origines des alchimie*, 1885, p. 60.

[2] *Les Remonstrances ou la complaint de nature a l'alchimist errant.* Attributed to Jehan de Meung, who with Guillaume de Lorris wrote the *Roman de la Rose*. M. Méon, the editor of the edition of 1814 of this celebrated work, doubts, however, whether the attribution of the *complaint de nature* to Meung is correct.

[3] "La Metallurgie in France," 1894, p. 2.

The dualism we so often recognise in human life becomes allotropism in metals, and they, strangely enough, seem to be restricted to a single form of existence if they are absolutely free from contamination, for probably an absolutely pure metal cannot pass from a normal to an allotropic state. Last, it may be claimed that some metals possess attributes which are closely allied to moral qualities, for, in their relations with other elements, they often display an amount of discrimination and restraint that would do credit to sentient beings.

Close as this resemblance is, I am far from attributing consciousness to metals, as their atomic changes result from the action of external agents, while the conduct of conscious beings is not determined from without, but from within. I have, however, ventured to offer the introduction of this lecture in its present form, because any facts which lead us to reflect on the unity of plan in nature, will aid the recognition of the complexity of atomic motion in metals upon which it is needful to insist.

The foregoing remarks have special significance in relation to the influence exerted by the rarer metals on the ordinary ones. With exception of the action of carbon upon iron, probably nothing is more remarkable than the action of the rare metals on those which are more common; but their peculiar influence often involves, as we shall see, the presence of carbon in the alloy.

Which, then, are the rarer metals, and how may they be isolated? The chemist differs somewhat from the metallurgist as to the application of the word "rare." The chemist thinks of the "rarity" of a compound of a metal; the metallurgist, rather of the difficulty of isolating the metal from the state of combination in which it occurs in nature.

The chemist in speaking of the reactions of salts of the rarer metals, in view of the wide distribution of limestone and pyrolusite, would hardly think of either calcium or manganese as being among the rarer metals. The metallurgist would consider pure calcium or pure manganese to be very rare, I have only recently seen comparatively pure specimens of the latter.

The metals which, for the purposes of this lecture, may be included among the rarer metals are: (1) those of the platinum group, which occur in nature in the metallic state; and (2) certain metals which in nature are usually found as oxides or in an oxidised form of some kind, and these are chromium, manganese, vanadium, tungsten, titanium, zirconium, uranium, molybdenum (which occurs, however, as sulphide). Incidental reference will be made to nickel and cobalt.

Of the rare metals of the platinum group I propose to say but little; we are indebted for a magnificent display of them in the library to my friends Messrs. George and Edward Matthey and to Mr. Sellon, all members of a great firm of metallurgists. You should specially look at the splendid mass of palladium, extracted from native gold of the value of £2,500,000, at the melted and rolled iridium, and at the masses of osmium and rhodium. No other nation in the world could show such specimens as these, and we are justly proud of them.

These metals are so interesting and precious in themselves, that I hope you will not think I am taking a sordid view of them by saying that the contents of the case exhibited in the library are certainly not worth less than ten thousand pounds.

As regards the rarer metals which are associated with oxygen, the problem is to remove the oxygen, and this is usually effected either by affording the oxygen an opportunity for uniting with another metal, or by reducing the oxide of the rare metal by carbon, aided by the tearing effect of an electric current. In this crucible there is an intimate mixture, in atomic proportions, of oxide of chromium and finely divided metallic aluminium. The thermo-junction (A, Fig. 1) of the pyrometer which formed the subject of my last Friday evening lecture here, is placed within the crucible, B, and the spot of light, C, from the galvanometer, D, with which it is connected, indicates on the screen that the temperature is gradually rising. You will observe that as soon as the point marked 1010° is reached, energetic action takes place: the temperature suddenly rising above the melting-point of platinum, melts the thermo-junction, and the spot of light swings violently; but if the crucible be broken open, you will see that a mass of metallic chromium has been liberated.

The use of alkaline metals in separating oxygen from other metals is well known. I cannot enter into its history here, beyond saying that if I were to do so, frequent references to

the honoured names of Berzelius, Wöhler, and Winkler would be demanded.[1]

Mr. Vautin has recently shown that granulated aluminium may readily be prepared, and that it renders great service when employed as a reducing agent. He has lent me many specimens of rarer metals which have been reduced to the metallic state by the aid of this finely-granulated aluminium; and I am indebted to his assistant, Mr. Picard, who was lately one of my own students at the Royal School of Mines, for aid in the preparation of certain other specimens which have been isolated in my laboratory at the Mint.

The experiment you have just seen enables me to justify a statement I made respecting the discriminating action which certain metals appear to exert. The relation of aluminium to other metals is very singular. When, for instance, a small quantity of aluminium is present in cast-iron, it protects the silicon, manganese, and carbon from oxidation.[2] The presence of silicon in aluminium greatly adds to the brilliancy with which aluminium itself oxidises and burns.[3] It is also asserted that aluminium, even in small quantity, exerts a powerful protective action against the oxidation of the silver-zinc alloy which is the result of the desilverisation of lead by zinc.

Moreover, heat aluminium in mass to redness in air, where oxygen may be had freely, and a film of oxide which is formed will protect the mass from further oxidation. On the other hand, if finely divided aluminium finds itself in the presence of an oxide of a rare metal, at an elevated temperature, it at once acts with energy and promptitude, and releases the rare metal from the bondage of oxidation. I trust, therefore, you will consider my claim that a metal may possess moral attributes has

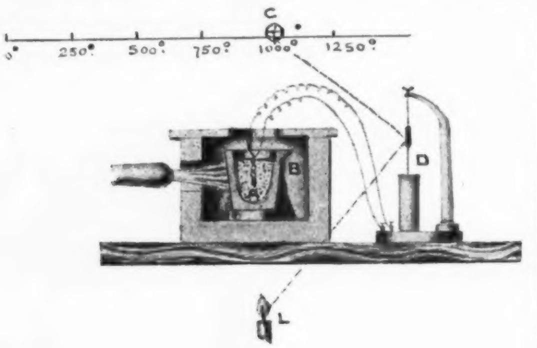

FIG. 1

been justified. Aluminium, moreover, retains the oxygen it has acquired with great fidelity, and will only part with it again at very high temperatures, under the influence of the electric arc in the presence of carbon.

[A suitable mixture of red-lead and aluminium was placed in a small crucible heated in a wind furnace, and in two minutes an explosion announced the termination of the experiment. The crucible was shattered to fragments.]

The aluminium loudly protests, as it were, against being entrusted with such an easy task, as the heat engendered by its oxidation had not to be used in melting a difficultly fusible metal like chromium, the melting point of which is higher than that of platinum.

It is admitted that a metal will abstract oxygen from another metal if the reaction is more exothermic than that by which the oxide to be decomposed, was originally formed. The heat of formation of alumina is 391 calories, that of oxide of lead is 51 calories; so that it might be expected that metallic aluminium, at an elevated temperature, would readily reduce oxide of lead to the metallic state.

The last experiment, however, proved that the reduction of oxide of lead by aluminum is effected with explosive violence, the temperature engendered by the reduction being sufficiently high to volatilise the lead. Experiments of my own show that the explosion takes place with much disruptive power when aluminium reacts on oxide of lead *in vacuo*, and that if coarsely ground, fused litharge be substituted for red lead, the action is only accompanied by a rushing sound. The result is, therefore, much influenced by the rapidity with which the reaction can be transmitted throughout the mass. It is this kind of experiment which makes us turn with such vivid interest to the teaching of the school of St. Claire Deville, the members of which have rendered such splendid services to physics and metallurgy. They do not advocate the employment of the mechanism of molecules and atoms in dealing with chemical problems, but would simply accumulate evidence as to the physical circumstances under which chemical combination and dissociation take place, viewing these as belonging to the same class of phenomena as solidification, fusion, condensation, and evaporation. They do not even insist upon the view that matter is minutely granular, but in all cases of change of state, make calculations on the basis of work done, viewing changed "internal energy" as a quantity which should reappear when the system returns to the initial state.

A verse, of some historical interest, may appeal to them. It occurs in an old poem to which I have already referred as being connected with the *Roman de la Rose*, and it expresses nature's protest against those who attempt to imitate her works by the use of mechanical methods. The "argument" runs thus:—

"Comme nature se complaint,
Et dit sa douleur et son plaint,
A ung sot souffleur sophistique,
Qui n'use que d'art méchanique."

If the "use of mechanical art" includes the study of chemistry on the basis of the mechanics of the atoms, I may be permitted to offer the modern school the following rendering of nature's plaint:—

"How nature sighs without restraint,
And grieving makes her sad complaint
Against the subtle sophistry
Which trusts atomic theory."

An explosion such as is produced when aluminium and oxide of lead are heated in presence of each other, which suggested the reference to the old French verse, does not often occur, as in most cases the reduction of the rarer metals by aluminium is effected quietly.

Zirconium is a metal which may be so reduced. I have in this way prepared small quantities of zirconium from its oxide, and have formed a greenish alloy of extraordinary strength by the addition of $\frac{1}{10}$ per cent. of it to gold, and there are many circumstances which lead to the belief that the future of zirconium will be brilliant and useful. I have reduced vanadium and uranium from its oxide by means of aluminium as well as manganese, which is easy, and titanium, which is more difficult. Tungsten, in fine specimens, is also before you, and allusion will be made subsequently to the uses of these metals. At present I would draw your attention to some properties of titanium which are of special interest. It burns with brilliant sparks in air; and as few of us have seen titanium burn, it may be well to burn a little in this flame. [Experiment performed.] Titanium appears to be, from the recent experiments of M. Moissan, the most difficultly fusible metal known; but it has the singular property of burning in nitrogen—it presents, in fact, the only known instance of vivid combustion in nitrogen.[1]

Titanium may be readily reduced from its oxide by the aid of aluminium. Here are considerable masses, sufficiently pure for many purposes, which I have recently prepared in view of this lecture.

The other method by which the rarer metals may be isolated is that which involves the use of the electrical furnace. In this connection the name of Sir W. Siemens should not be forgotten. He described the use of the electric arc-furnace in which the carbons were arranged vertically, the lower carbon being replaced by a carbon crucible, and in 1882 he melted in such a furnace no less than ten pounds of platinum during an experiment at which I had the good fortune to assist. It may fairly be claimed that the large furnaces with a vertical carbon in which aluminium and other metals are now reduced by the combined electrolytic action and tearing temperature of the arc, are the direct outcome of the work of Siemens.

In the development of the use of the electric arc for the isolation of the rare, difficultly fusible, metals Moissan stands

[1] An interesting paper, by H. F. Keller, on the reduction of oxides of metals by other metals, will be found in the *Journal* of the American Chemical Society, December 1894, p. 833.
[2] *Bull. Soc. Chim.* Paris, vol. xi. 1894, p. 377.
[3] "Ditte Leçons sur les Métaux," part ii. 1891, p. 206.

[1] Lord Rayleigh has since stated that titanium does not combine with argon; and M. Guntz points out that lithium in combining with nitrogen produces incandescence.

in the front rank. He points out[1] that Deprez[2] used in 1849, the heat produced by the arc of a powerful pile; but Moissan was the first to employ the arc in such a way as to separate its heating effect from the electrolytic action it exerts. This he does by placing the poles in a horizontal position, and by reflecting their heat into a receptacle below them. He has shown, in a series of classical researches, that employing 800 amperes and 110 volts a temperature of at least 3500° may be attained, and that many metallic oxides which until recently were supposed to be irreducible may be readily made to yield the metal they contain.[3]

A support or base for the metal to be reduced is needed, and this is afforded by magnesia, which appears to be absolutely stable at the utmost temperatures of the arc. An atmosphere of hydrogen may be employed to avoid oxidation of the reduced metal, which, if it is not a volatile one, remains at the bottom of the crucible almost always associated with carbon—forming, in fact, a carbide of the metal. I want to show you the way in which the electric furnace is used, but unfortunately the reductions are usually very tedious, and it would be impossible to actually show you much if I were to attempt to reduce before you any of the rarer metals; but as the main object is to show you how the furnace is used, it may be well to *boil* some silver at a temperature of some 2500°, and subsequently to melt chromium in the furnace (Fig. 2). This furnace consists of a clay receptacle, A, lined with magnesia, B. A current of 60 amperes and 100 volts is introduced by the carbon poles, C, C; an electro-magnet, M, is provided to deflect the arc on to the metal to be melted. [By means of a lens and mirror, D, E, the image of the arc and of the molten metal was projected on to a screen. For this purpose it was found convenient to make the furnace much deeper than would ordinarily be the case.]

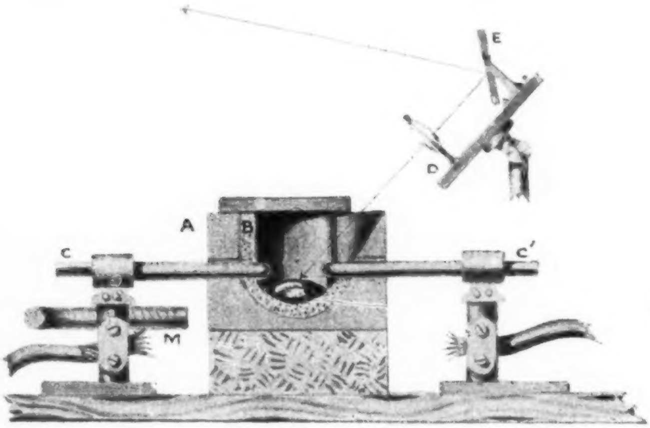

FIG. 2.

It must not be forgotten that the use of the electric arc between carbon poles renders it practically impossible to prepare the rare metals without associating them with carbon, often forming true carbides; but it is possible in many cases to separate the carbon by subsequent treatment. Moissan has, however, opened up a vast field of industrial work by placing at our disposal practically all the rarer infusible metals which may be reduced from oxides, and it is necessary for us now to consider how we may best enter upon our inheritance. Those members of the group which we have known long enough to appreciate are chromium and manganese, and these we have only known free from carbon for a few months. In their carburised state they have done excellent service in connection with the metallurgy of steel; and may we not hope that vanadium, molybdenum, titanium, and uranium will render still greater services? My object in this lecture is mainly to introduce you to these metals, which hitherto few of us have ever seen except as minute cabinet specimens, and we are greatly indebted to M. Moissan for sending us beautiful specimens of chromium, vanadium, uranium, zirconium, tungsten, molybdenum, and titanium. [These were exhibited.]

The question naturally arises: Why is the future of their usefulness so promising? Why are they likely to render better service than the common metals with which we have long been familiar? It must be confessed that as yet we know but little what services these metals will render when they stand alone; we have yet to obtain them in a state of purity, and have yet to study their properties, but when small quantities of any of them are associated or alloyed with other metals, there is good reason to believe that they will exert a very powerful influence. In order to explain this, I must appeal to the physical method of inquiry to which I have already referred.

It is easy to test the strength of a metal or of an alloy; it is also easy to determine its electrical resistance. If the mass stands these tests well, its suitability for certain purposes is assured; but a subtle method of investigation has been afforded by the results of a research entrusted to me by a committee of

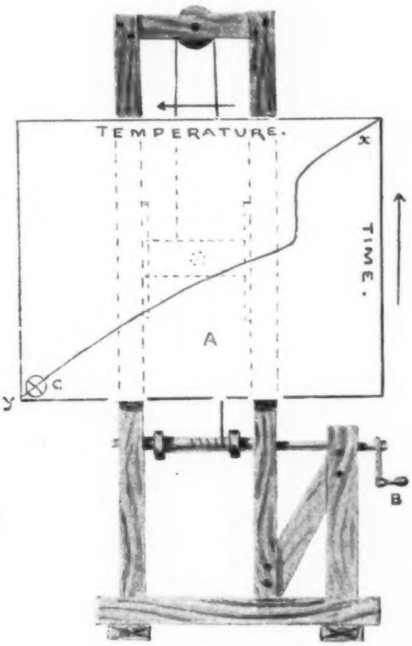

FIG. 3.

the Institution of Mechanical Engineers, over which Dr. Anderson, of Woolwich, presides. We can now gather much information as to the way in which a mass of metal has arranged itself during the cooling from a molten condition, which is the necessary step in fashioning it into a useful form; it is possible to gain insight into the way in which a molten mass of a metal or an alloy, molecularly settles itself down to its work, so to speak, and we can form conclusions as to its probable sphere of usefulness.

The method is a graphic one, such as this audience is familiar with, for Prof. Victor Horsley has shown in a masterly way that traces on smoked paper may form the record of the heart's action under the disturbing influence caused by the intrusion of a bullet into the human body. I hope to show you by similar records the effect, which though disturbing is often far from prejudicial, of the introduction of a small quantity of a foreign element into the "system" of a metal, and to justify a statement which I made earlier, as to the applicability of physiological methods of investigation to the study of metals. In order that the nature of this method may be clear, it

[1] *Ann. de Chim. et de Phys.* vol. iv. 1895, p. 365.
[2] *Comptes rendus*, vol. xxix. 1849, p. 48, 545, 712.
[3] The principal memoirs of M. Moissan will be found in the *Comptes rendus*, vol. cxv. 1892, p. 1031; *ibid.* vol. cxvi. 1893, pp. 347, 349, 549, 1222, 1225, 1429; *ibid.* vol. cxix. 1894, pp. 15, 20, 935; *ibid.* vol. cxx. 1895, p. 290. The more important of the metals he has isolated are uranium, chromium, manganese, zirconium, molybdenum, tungsten, vanadium, and titanium. There is an important paper by him on the various forms of the electric furnace in the *Ann. de Chim. et de Phys.* vol. iv. 1895, p. 365.

must be remembered that if a thermometer or a pyrometer, as the case may be, is plunged into a mass of water or of molten metal, the temperature will fall continuously until the water or the metal begins to become solid; the temperature will then remain constant until the whole mass is solid, when the downward course of the temperature is resumed. This little thermo-junction is plunged into a mass of gold; an electric current is, in popular language, generated, and the strength of the current is proportional to the temperature to which the thermo-junction is raised; so that the spot of light from a galvanometer to which the thermo-junction is attached enables us to measure the temperature, or, by the aid of photography, to record any thermal changes that may occur in a heated mass of metal or alloy.

It is only necessary for our purpose to use a portion of the long scale, and to make that portion of the scale movable. Let me try to trace before you the curve of the freezing of pure gold. It will be necessary to mark the position occupied by the movable spot of light at regular intervals of time during which the gold is near 1045°, that is, while the metal is becoming solid. Every time a metronome beats a second, the white screen A (Fig. 3), a sheet of paper will be raised a definite number of inches by the gearing and handle, B, and the position successively occupied by the spot of light, C, will be marked by hand.

You see that the time-temperature curve, x, y, so traced is not continuous. The freezing point of the metal is very clearly marked by the horizontal portion. If the gold is very pure the angles are sharp, if it is impure they are rounded. If the metal had fallen below its freezing point without actually becoming solid, that is, if superfusion or surfusion had occurred, then there would be, as is often the case, a dip where the freezing begins, and then the temperature curve rises suddenly.

If the metal is alloyed with large quantities of other metals, then there may be several of these freezing points, as successive groups of alloys fall out of solution. The rough diagrammatic method is not sufficiently delicate to enable me to trace the subordinate points, but they are of vital importance to the strength of the metal or alloy, and photography enables us to detect them readily.

Take the case of the tin-copper series; you will see that as a mass of tin-copper alloy cools, there are at least two distinct freezing points. At the upper one the main mass of the fluid alloy became solid; at the lower, some definite group of tin and copper atoms fall out, the position of the lower point depending upon the composition of the mass.

(To be continued.)

THE INSTITUTION OF MECHANICAL ENGINEERS.

THE ordinary spring meeting of the Institution of Mechanical Engineers was held on Wednesday and Friday evening of last week, April 24 and 26, the President, Prof. Alexander B. W. Kennedy, F.R.S., occupying the chair both evenings. The following was down on the agenda of the meeting: Adjourned discussion on Captain H. Riall Sankey's paper on "Governing of Steam Engines by Throttling and by Variable Expansion"; the "Third Report to the Alloys Research Committee," by Prof. W. C. Roberts-Austen, C.B., F.R.S., "Appendix on the Elimination of Impurities during the Process of making 'Best Selected' Copper," by Mr. Allan Gibb; "Appendix on the Pyrometric Examination of the Alloys of Copper and Tin," by Mr. Alfred Stansfield.

In the discussion on Captain Sankey's paper a number of members spoke. As a general result it may be stated that the position taken by the author in his paper was supported, viz.: that for certain purposes, governing by means of the throttle valve was to be preferred; whilst under other conditions variable expansion governors would have advantages over the other method. Captain Sankey in his contribution impartially discussed both systems, and his paper may be taken as a good model of what a memoir of the kind should be, no undue bias being shown on either side.

The report of Prof. Roberts-Austen was perhaps of even greater interest than those which have preceded it; whilst the two appendices of Messrs. Gibb and Stansfield discussed important practical details. A request had been made that the investigations of Warburg and Tegetmeier on molecular porosity, and their observations on the "Electrolysis of Glass"[1] should be repeated. It will be remembered that atoms of sodium were made to pass through glass at a temperature of 200° C. under the influence of the electric current. Lithium atoms were then made to follow along the tracks or molecular galleries left by the sodium, the lithium having a lower atomic volume and weight than the sodium. When potassium, having a higher atomic weight and volume, was substituted, it was not found possible to trace out the sodium. We are thus, the author said, confronted with a molecular porosity which can in a sense be gauged, and the mechanical influence of the volume of the atom is thus made evident. It will also be evident that there is a direct connection between the properties of a mass and the volume of its atoms. The results previously obtained were entirely confirmed and somewhat extended in the experiments the author had undertaken. The septa, or dividing partitions, in these fresh experiments, were made mostly of soda glass, of which thick bulbs were blown from barometer tube. In most of the experiments the glass was electrolysed, using mercury and an amalgam of some metal as cathode and anode respectively. The temperature was from 250° to 350° C. The electromotive force employed was 100 volts, and the current in the case of the sodium experiments averaged about one-thousandth of an ampere, and was sometimes as high as one-fiftieth of an ampere. When the glass bulbs were employed they soon became cracked, and the free passage of the current fused the glass, forming a well-rounded hole. In each experiment a safety fuse was placed in series, to stop the current in case of breakage. In experiments in which sodium amalgam had been placed in the bulb and pure mercury outside, sodium passed into the mercury to the extent of 0·03 gramme or 0·46 grain. In one experiment, which lasted eighteen hours, the amount of sodium found in the mercury was 0·0131 gramme, or 0·2022 grain. The quantity of electricity which passed through the glass was measured by the aid of an electrolytic cell placed in series, in which copper was deposited to the amount of 0·0206 gramme, or 0·3179 grain. Calculating the number of coulombs of electricity passed by means of the electrolysis of glass, the number 55 is found, and by the electrolysis of copper sulphate, 62; thus showing, as well as a rough approximate experiment could, that the passage of sodium into the mercury follows the ordinary law of electrolysis. It is doubtful whether the sodium from the amalgam actually penetrated right through the glass; but there can be no question that it replaced a considerable proportion of the sodium which the glass contained. An attempt to pass potassium through the same glass failed. Gold was then used, both in the form of amalgam and dissolved in metallic lead, but in the latter case the temperature employed was, of course, higher. No gold was found to have been transmitted through the glass; but the glass employed became coloured by gold, and minute spangles of the metal were found embedded in it. The same result was obtained when copper was used as an amalgam; and in this case minute nodules of copper were deposited below the surface of the glass, an effect which is highly suggestive in connection with the formation of mineral veins by earth currents. Sodium amalgam placed in a bulb and surrounded with mercury, but with no current, gave negative results, showing that simple diffusion did not play any important part in the results obtained. The fact that a current passes at all through glass is a proof that electrolytic action has taken place; so that, even if a metal be not actually transmitted through glass, the passage of a current indicates that sodium, potassium, or other metallic constituent of the glass, must be leaving it, and is probably replaced by one or more of the metals in the metallic bath which constitutes the anode.

The author next referred to an addition made to the recording pyrometer by means of which increased sensitiveness was obtained. The galvanometer, which affords the means of measuring the temperatures of the masses of metal or alloy under examination, may occupy one of two positions; it may either be nearer to the slit through which the ray of light falls upon the photographic plate, or it may be further away from it. It will be evident that two galvanometers may be used simultaneously, with the light from their respective mirrors playing

[1] E. Warburg, "Ueber die Elektrolyse des festen Glases," *Wiedemann's Annalen*, vol. xxi. 1884, p. 622. E. Warburg and F. Tegetmeier, "Ueber die elektrolytische Leitung des Bergkrystalls," *Wiedemann's Annalen*, vol. xli., 1890, page 18. E. Warburg, "Ueber eine Methode Natrium Metall in geisslersche Röhren einzuführen," *Wiedemann's Annalen*, vol. xl. 1890, page 1.

through the same slit upon the photographic plate. The further galvanometer can have a much lower resistance, and consequently greater delicacy, than the nearer one, so that, while the line photographed on the moving sensitised plate from the nearer galvanometer might represent a range of temperature of, say, 1500 degrees, the line traced by the mirror of the further galvanometer should represent only one-tenth of this. The angular deflection of the nearer mirror would not exceed the limits of the sensitised plate, while the mirror of the delicate galvanometer might traverse a far larger range. Both galvanometers would be connected "in parallel" with the same thermo-junction; and obviously any portion of the extended range which it was desirable to reflect on the sensitised plate could easily be caught by a suitable adjustment of the mirror on the further galvanometer. If, therefore, the thermo-junction is plunged into a mass of metal cooling from say an initial temperature of 1500 degrees, the whole of the cooling curve could be traced by the mirror of the less delicate galvanometer, while only the portion greatly magnified would be recorded by the mirror of the more delicate galvanometer. The first curve derived from the less delicate galvanometer would serve as a "calibration curve" for that afforded by the other galvanometer.

By means of diagrams exhibited on the walls of the theatre, a large number of cooling curves for electro-iron were shown, care being taken that the iron was exceedingly pure. The points of recalescence were well shown on these curves, which may be studied with interest in the *Transactions* of the Institution, as bearing on the question of allotropy of iron, which has already been fully discussed in a former report. The cooling-curve of an aluminium-copper alloy was also given. This was the alloy containing 6 per cent. of copper, used by Mr. Yarrow in the construction of torpedo boats for the French Government. Two freezing points were shown, one due to the main mass, and the other at a lower point due to the copper associated with the aluminium. The pyrometric examination of iron-aluminium alloys was also treated at some length, but it would be difficult to give results without reproducing the curves and the diagram shown.

One feature that may be noticed, however, was that the freezing point of iron alloyed with, say, one per cent. of aluminium, is but little lower than that of iron itself; that is to say, the melting point of nearly pure iron is only slightly lowered by a small addition of aluminium. Osmond had already shown that aluminium does not produce any considerable lowering of the freezing point of cast-iron; and the usually accepted idea that cast-iron or steel containing aluminium is very fusible, must be due to the fluidity of the metal when it is melted.

Another interesting point was that the samples of alloys used in these experiments were kept for some months before being analysed, and it was found that during this time those which contained from 40 to 60 per cent. of aluminium had spontaneously disintegrated, and had fallen to powder. The powder was not oxidised, but consisted of clean metallic grains, probably resulting from chemical changes which had gradually taken place in the solid alloy. Whether the iron and aluminium were in a state of solution or were chemically combined when molten, there can be little doubt that they are so combined in the metallic powder, as attempts to re-melt this powder have proved unsuccessful, which points to the formation of an infusible compound.

Some experiments made by Mr. Thomas Wrightson to ascertain whether the welding of iron is attended with a fall of temperature, as is the case in the regelation of ice, were next described. The welding was done by means of electricity and observations were taken by means of the pyrometer formerly described. The results have been communicated to the Royal Society, and tend to show that the welding of iron and the regelation of ice are analogous phenomena, a point of no small theoretical importance.

In his last report the author had called attention to the fact that M. André Le Chatélier had suggested that the prejudicial action of an element is due to its forming a fusible compound with the metallic mass in which it is hidden; while, on the other hand, the presence of an element which forms an infusible compound with the mass, promotes the formation of a fine grain and imparts strength. The author did not wish it to be supposed, however, that the action of the added element is due solely to its infusibility, or to its power of forming a fusible compound with a portion of the mass which contains it; for cases are numerous in which such an explanation does not apply. In this connection a suggestion made long ago by Raoult Pictet (*Comptes rendus*, vol. lxxxviii. 1879, pp. 855 and 1315), well deserved consideration. He urged that there must be a connection between the melting-points of metals and the periodic law of Mendeléeff; for he showed that for all metals there is a simple relation between their atomic weight, the amplitude of the movement of their molecules under the influence of heat, and their melting-point. Pure metals with high melting-points—such as platinum, iron, copper, and gold—are comparatively strong; and, conversely, metals with low melting-points—zinc, lead, cadmium, bismuth, and tin—are relatively weak. Metals with high melting-points must necessarily be coherent and tenacious, because much heat is required to drive their molecules apart in reducing them to the liquid mobile state in which the molecules have very small coherence; and therefore at ordinary temperatures much force must be applied to overcome the cohesion of the molecules and break the mass. Conversely, in metals with low melting-points a small elevation of temperature will overcome the molecular cohesion, and render them liquid—that is, will melt them. Such metals will be weak, the author continued, because if little heat is required to melt the metal, less force will be needed to tear it apart. Hence melting-point and tenacity are clearly connected. The absolute temperature of the melting-point of a metal must be closely connected with its atomic volume, because the former is inversely proportional to the rate at which the amplitude of the oscillations of the molecules increases with temperature; and the rate of increase of amplitude at any given temperature is obtained by multiplying the ordinary thermal coefficient of linear expansion by the cube root of the atomic volume.

Prof. Roberts-Austen here pointed out that the recent work of Dewar and Fleming (*Philosophical Magazine*, vol. xxxiv. 1892, p. 326) bears directly on this question. They employed very low temperatures, and show that at the absolute zero of temperature pure metals would probably offer no resistance to the passage of an electric current, but that the electrical resistance of alloys does not diminish so rapidly with the lowering of temperature as in the case of pure metals. Prof. Dewar (*Proceedings* of the Royal Institution, vol. xiv. part 2, 1895, p. 1) has shown, moreover, that the tenacity of pure metals and alloys is greatly increased by extreme cold—that is, by the closer approximation of their molecules; and this affords additional evidence that metals become stronger at temperatures which are further and further removed from their melting-points.

The discussion on this paper was of a somewhat brief nature, the reading of the report and the appendices, together with the carrying out of certain experiments and illustrations, taking a considerable time. Mr. Wrightson also explained at some length his welding experiments, which, as stated, have been placed before the Royal Society.

Prof. Goodman, of Leeds, gave some interesting particulars of the work upon which he has been engaged during the last two years in connection with anti-friction alloys. He had discovered that these substances must always contain a metal of high atomic volume, and there seemed to be a direct connection between the efficiency of the anti-friction of alloy and the atomic volume of one of its constituents. If the atomic volume of the alloy were small, then the friction was enormously increased, but with high atomic volume it was reduced. He had produced an anti-friction metal which would withstand a pressure of two tons to the square inch when running at 550 revolutions per minute, the temperature being 140°; that was a very remarkable result for a white metal. The alloy used had a higher atomic volume than bismuth, but he was not at liberty then to state the nature of the substance. He wished, however, to impress the necessity of absolute purity, or that if there were any impurities, they should be of high atomic volume.

Mr. Blount, in referring to the author's remarks on the electrolysis of glass, and the fact that potassium would not follow sodium and lithium, said he would be glad of an explanation why gold, which had a lower atomic volume than sodium, should not have traversed the "galleries" left in the glass by the sodium.

The summer meeting of the Institution will be held in Glasgow, commencing Tuesday, July 30.

THE ROYAL COMMISSION ON TUBERCULOSIS.

IN July 1890, a Royal Commission was appointed to inquire and report "what is the effect, if any, of food derived from tuberculous animals on human health, and if prejudicial, what are the circumstances and conditions with regard to the tuber-

culosis in the animal which produces that effect upon man. Lord Basing was the chairman, and the other commissioners were: Prof. G. T. Brown, Sir George Buchanan, Dr. G. F. Payne, and Prof. Burdon Sanderson. After the death of Lord Basing, in October last, the commission was reorganised with Sir George Buchanan as chairman. The report of this commission, upon the evidence and experimental inquiries received since the appointment of the original commission five years ago, was presented to Parliament last week. The general results of the inquiries instituted by the commissions in connection with the matter referred to them, will be found in the subjoined summary appended to the report:—

"We have obtained ample evidence that food derived from tuberculous animals can produce tuberculosis in healthy animals. The proportion of animals contracting tuberculosis after experimental use of such food is different in one and another class of animals; both carnivora and herbivora are susceptible, and the proportion is high in pigs. In the absence of direct experiments on human subjects we infer that man also can acquire tuberculosis by feeding upon materials derived from tuberculous food animals. The actual amount of tuberculous disease among certain classes of food animals is so large as to afford to man frequent occasions for contracting tuberculous disease through his food. As to the proportion of tuberculosis acquired by man through his food or through other means we can form no definite opinion, but we think it probable that an appreciable part of the tuberculosis that affects man is obtained through his food. The circumstances and conditions with regard to the tuberculosis in the food animal which lead to the production of tuberculosis in man are, ultimately, the presence of active tuberculous matter in the food taken from the animal and consumed by the man in a raw or insufficiently cooked state. Tuberculous disease is observed most frequently in cattle and in swine. It is found far more frequently in cattle (full grown) than in calves, and with much greater frequency in cows kept in town cowhouses than in cattle bred for the express purpose of slaughter. Tuberculous matter is but seldom found in the meat substance of the carcase; it is principally found in the organs, membranes, and glands. There is reason to believe that tuberculous matter, when present in meat sold to the public, is more commonly due to the contamination of the surface of the meat with material derived from other diseased parts than to disease of the meat itself. The same matter is found in the milk of cows when the udder has become invaded by tuberculous disease, and seldom or never when the udder is not diseased. Tuberculous matter in milk is exceptionally active in its operation upon animals fed either with the milk or with dairy produce derived from it. No doubt the largest part of the tuberculosis which man obtains through his food is by means of milk containing tuberculous matter. The recognition of tuberculous disease during the life of an animal is not wholly unattended with difficulty. Happily, however, it can in most cases be detected with certainty in the udders of milch cows. Provided every part that is the seat of tuberculous matter be avoided and destroyed, and provided care be taken to save from contamination by such matter the actual meat substance of a tuberculous animal, a great deal of meat from animals affected by tuberculosis may be eaten without risk to the consumer. Ordinary processes of cooking applied to meat which has got contaminated on its surface are probably sufficient to destroy the harmful quality. They would not avail to render wholesome any piece of meat that contained tuberculous matter in its deeper parts. In regard to milk, we are aware of the preference by English people for drinking cows' milk raw—a practice attended by danger on account of possible contamination by pathogenic organisms. The boiling of milk, even for a moment, would probably be sufficient to remove the very dangerous quality of tuberculous milk. We note that your Majesty's gracious commands do not extend to inquiry or report on administrative procedures available for reducing the amount of tuberculous material in the food supplied by animals to man, and we have regarded such questions as being beyond our province."

THE GEOLOGICAL DEVELOPMENT OF AUSTRALIA.

BY the kindness of the Secretary of the Australasian Association for the Advancement of Science, we have been favoured with a complete account of the proceedings of the late meeting at Brisbane. The Hon. A. C. Gregory, C.M.G., the president of the meeting, took as the subject of his address "The Geographical History of the Australian Continent during its successive Phases of Geological Development." The subject afforded Mr. Gregory an opportunity for putting on record the knowledge he has gained from personal inspection of a larger proportion of Australian territory than has been explored by any other investigator. We are glad to be able to give the text of his address.

PRIMARY CONDITION AND FORM OF LAND.

In dealing with the geological history of Australia, it is convenient to refer to the groups of formation, as the scope of this address is insufficient for the separate consideration of the component members of each group which has taken prominent part in the geographical establishment of sea and land. Like all histories of remote events, the evidence of what was the primary condition and form of the land is necessarily of very limited character, but some evidence does remain for our guidance. The earliest indications of the existence of land within the limits of the present Australian continent consists in the fact that many of the more elevated summits are composed of "granite," which is certainly the oldest rock formation with which we are acquainted.

It is here necessary to state that the term granite is used to indicate ancient or continental granite, and that the granitoid rocks, which are so closely allied in lithological aspect as to pass under the same designation, but are really intrusive masses of more recent date, even as late as the Permo-carboniferous period will be termed intrusive granite. Now the higher portions of the granite ranges show no superincumbent strata, while sedimentary beds fold round their flanks in a manner which indicates that the edges of these strata were formed near the margin of an ancient sea, above which the more elevated masses of granite rose as islands. As an instance of this early existence of land, we find on the present east coast that the granite tract of New England is flanked by Devonian slates and marine beds of spirifer limestones in positions which indicate that their deposition was in an ocean of at least 2000 feet in depth, above which the granite mountains rose to an elevation of 2000 feet. Adopting similar evidence as a basis for the estimation of the area of land at this earlier date, it appears that there existed a chain of islands extending from Tasmania northerly along the line of the present great dividing range, between the eastern and western streams nearly to Cape York, a distance of about 2000 miles, and with a breadth seldom exceeding 100 miles. In Western Australia a much broader area of dry land existed in the form of a granite tableland, the western limit of which, commencing at Cape Leeuwin, extended north for 600 miles, with a straight coast-line rising 500 feet to 1000 feet above the ocean. This land had a breadth east and west of about 200 miles, but its eastern shores were comparatively low and irregular, with probably detached insular portions, more especially on the northern side, as the stratified rocks in which the West Australian gold mines are worked have an exceedingly irregular outline where they overlay the granite. Between these eastern islands and the western land, there probably existed some granite peaks which rose above the ocean, but the evidence is that they were not of important area, and principally located in the northern parts. The remainder of the present continent was covered by an ocean gradually increasing in depth from the western land to the central part, and great depth continued to the shores of the eastern islands.

SEDIMENTARY DEPOSITS.

The next step in our history is that the natural decomposition of the granite, both terrestrial and marine, supplied material for sedimentary deposits; and we find a series of imperfectly stratified grit rocks, together with schists and slates, the former the results of the deposition of the coarser drifts, and the latter the more gradual deposit of the finer particles. These rocks, which are classed as Laurentian, Cambrian, and Silurian, did not extend far from the eastern islands, and are principally developed in Queensland to the north and in Victoria to the south, but, being of marine formation, they did not then materially affect the geographical configuration, though they are important features of the present time, and are the chief sources of our tin mines; and silver, lead, and copper also exist in sufficient quantity to afford prospect of future industrial success. There is also a marked characteristic in the abundant occurrence of fluor spar, which is an exceedingly rare mineral in the later formations.

while gold does not occur in important quantity except in its upper or Silurian strata in Victoria. Near Zilmantown (lat. 17° 20′ S., long. 144° 30′ E.) there are interesting developments of these rocks, which now form steep ranges with flat-bottomed valleys, in which coralline limestone of the Devonian period rests unconformably, and in places rises abruptly several hundred feet, presenting the form of ancient coral reefs, such as now exist on the great Barrier Reefs. In fact, they indicate that at some remote time a passage existed from the east coast to the southern part of the Gulf of Carpentaria, under similar conditions to those of the present Torres Straits, and that the subsequent elevation of the land has now placed it more than 500 feet above sea-level. This description of the present state of these rocks is, however, a digression in regard to geological sequences of the early period.

MORE FAVOURABLE CONDITIONS.

The Cambrian and Silurian period was succeeded by the Devonian, during which there is little evidence of any great variation in the limits of the sea and land, but organic remains show that the conditions were becoming more favourable for the development of marine life. The rocks consist principally of fine-grained slates, which must have been deposited in a deep sea, and in some places the now visible sections indicate a thickness of 10,000 feet.

The upper strata connected with the Devonian series have been classed by geologists as belonging to the Permo-carboniferous, on account of the marine fossils which have been found in the Gympie series of rocks. Some difficulties, however, arise in regard to the identification of Australian rocks with those of Europe on the sole basis of the occurrence of nearly the same species of mollusca, and it may be remarked that in Central North America the appearance of fossil mollusca and plants, which would in Europe indicate a definite horizon, often occurs in rocks which lithologically and stratigraphically are of an earlier date; and the same conditions of the earlier appearance of species and genera seem to obtain in Australia, and if ultimately established would clear away many of the existing difficulties in the comparison of Australian and American fossils with those of Europe. Accepting the classification of the Gympie rocks as Permo-carboniferous, there was no important alteration in the geographical limits during the Devonian period, or in the earlier Permo-carboniferous Gympie beds, but shortly after this there were very decided variations in both the area and altitude of the land. The whole of the present continental area was raised sufficiently to lift large portions of the previous sea-bottom above its surface. The principal elevation was on the eastern coast, where the rise must have been several thousand feet; while on the west it was less pronounced, though the area added to the land appears to have included nearly the whole of what is now Western Australia. And in regard to the intervening space between it and the eastern ranges there is only the negative evidence, of no later marine deposits to indicate that it also was above the ocean. Although the general elevation of the continent appears to have been quiescent in the western and central parts, there were violent disruptions on the eastern coast, and the strata were apparently crushed by a force from the east which lifted them into a series of waves showing the faces of dislocation to the east and strata sloping to the west, the most easterly wave being near the present coast-line, and the succeeding waves more gradual as they recede to the west, both in angle and height, until they merge into the level of Central Australia. It is also probable that the South Australian range was also the result of this compression, causing the strata to rise in abrupt masses on an axis nearly north and south. It was at this stage of disruption and elevation of strata that the more important auriferous deposits of both the eastern and western parts of the continent were formed, and these may be divided into two classes—true fissure veins, or lodes, in which the deposits of ore are found filling fissures in the slate strata, and generally nearly vertical; and floors of ore which occur in sheets dipping at a less angle from the horizontal than the vertical, the including rock being of crystalline character, being, in fact, intrusive granites. The dip of these sheets of ore is in the direction of the huge dykes of intrusive rock in which they occur.

AURIFEROUS DEPOSITS IN LODES.

There was not only great disruption of the strata, but igneous rocks forced themselves into the fissures in the sedimentary beds, and the resulting metamorphism of the adjacent rocks increased the confusion, as beds of slate may be traced through the transformation of their sedimentary character, by the recrystallisation of their component elements into diorites having that peculiar structure of radiating crystals which usually characterise rocks of volcanic origin. As regards the auriferous deposits in these lodes, it appears that first simple fissures were filled with water from the ocean or deep-seated sources; but in either case the powerful electric currents which continually traverse the earth's surface east and west met resistance at the lines of disruption, and electric action being developed, the mineral and metallic salts in the water in the fissure and the adjacent rocks would be decomposed, and the constituents deposited as elements, such as gold and silver, or as compounds, such as quartz, calcspar, and sulphide of iron, all which were in course of deposit at the same time as the angles of the crystals cut into each other. There have been many speculations as to the source from which the gold was derived, but that which best accords with the actual conditions is that the metal exists in very minute quantities in the mass of the adjacent rocks, from which it has been transferred through the agency of electric currents and the solvent action of alkaline chlorides, which dissolve small quantities of the precious metals, and would be subject to decomposition at the places where fissures caused greater resistance to the electric current. One remarkable circumstance is that the character of the rocks forming the sides of the fissures has an evident influence on the richness of the ores in metals where lime, magnesia, or other alkaline compounds, or graphite, enter into their composition; the gold especially is more abundant than where the rocks contain silica and alumina only.

QUEENSLAND'S TESTIMONY.

In Queensland, Gympie affords some instructive examples of fissure lodes. In some, large masses of rock have fallen into the fissure before the ore was deposited, and have formed what miners term "horses," where the lode splits into two thin sheets to again unite below the fallen mass. The Mount Morgan mine may also be cited as a case where several fissure lodes rise to the surface in close proximity. The ore was originally an auriferous pyrites, but the sulphide of iron was largely decomposed, leaving the gold disseminated through the oxide of iron. In other cases the sulphur and iron have both been dissolved out, and left cellular quartz, with gold in the cavities or as fragments of gold, mixed with minute crystals of quartz, presenting the aspect of kaolin, for which it has been mistaken. The auriferous deposits, which occur in the intrusive granites, appear under conditions differing from the true lodes in sedimentary rocks, as the intrusive granitoid rock forms dykes which fill fissures in the older true granites, and also cut through the sedimentary slates. It bears evidence of intrusion in a state of fusion, or, at least, in plastic condition and subsequently crystallised, after which there has been shrinkage, causing cavities as the sides of the dyke were held in position by the enclosing rock. The vertical shrinkage being greater than the horizontal, the cavities were nearer the horizontal than the vertical, and being afterwards filled with ore, formed what are called "floors," one characteristic of which is the tendency to lenticular form, or a central maximum thickness with thinner edges. The Charters Towers goldfield exhibits a good illustration of this class of auriferous intrusive granite. Here the intrusive granite appears as a dyke of great thickness, exceeding a mile, with a length of twenty miles; the rock is well-crystallised quartz and felspar, with very little mica or hornblende. One shaft has been sunk 2000 feet to a floor showing gold, and similar to the floors that outcrop on the surface. The dip of these floors is north, about 30 degrees from the horizontal, and the strike across the direction of the dyke. There are, however, no good natural cross-sections, as the watercourses are small, so that the length and breadth have to be estimated to some extent by the character of the soil derived from the decomposed rock, it being more fertile than that of the other rocks in the locality. The exploratory shafts which have been sunk are in positions selected for the purpose of reaching known sheets of ore at greater depth, or under the impression that the ore deposits were true fissure lodes, and would have extension in the direction of the discovered outcrops, and therefore not calculated to extend our knowledge of the auriferous deposits. The most instructive instance of the occurrence of auriferous intrusive granite exists in the valley of the Brisbane River, near Eskdale, where a granitoid dyke, fifty yards wide, cuts through a slate hill for a distance of three miles, and in places shows thin sheets of quartz containing gold; the strike is at right angles to the length of the dyke, and the dip is 30 degrees. Some of the

quartz sheets have been traced across the dyke to within an inch of the slate which encloses it, but there is no trace of any variation in the sedimentary slate opposite the end of the quartz. A small watercourse cuts through the dyke and exposes arsenical pyrites and iron oxide, with small particles of gold. A more accessible instance of intrusive granite is exposed in the cutting for the bywash of the Brisbane Waterworks, at Enoggera, where the igneous rock has intruded between the strata of the slate.

PERMO-CARBONIFEROUS ROCKS.

From the middle to the close of the Permo-carboniferous period the dry land teemed with vegetation, of which the Lepidodendron was a conspicuous type, along the eastern division, for though this plant was most abundant in Queensland, it is also found in Victoria, and on the Philips River, in West Australia, where the later Permo-carboniferous rocks are found on the south coast, extending from Albany eastward to Israelite Bay, forming the Stirling Range, with an elevation of 3000 feet, the Mounts Barren, and Russell Range. The age of these rocks is determined by the occurrence of large fragments of carbonised vegetation, the aspect of which closely resemble Lepidodendron stems. This formation is limited to the coast district, as, at a distance of fifty miles inland, the granitic plateau is reached with its partial colouring of Devonian slates. On the northern coast the Permo-carboniferous rocks are developed in the valley of the Victoria River for a hundred miles from the sea. Also on the Kimberley goldfield, to the south-west of Victoria.

GEOGRAPHICAL FEATURES.

The geographical features of this period appear to have been a continent somewhat similar in form to that of the present Australia. There was an elevated range along the east coast which attracted moisture, and a climate favourable to vegetation, and also by rapid degradation of its rocks supplied suitable soil for tropical growth. The central interior was not favoured by such a climate, and there are few traces of either deposit or denudation. The western interior enjoyed a moderate rainfall, and the detritus was carried down towards the north and south coasts, where it was deposited in regions where the carboniferous flora flourished, though not to the same degree as in East Australia, where it laid the foundation of the great coalfields of New South Wales and Queensland.

FURTHER ELEVATION OF CONTINENT.

About the end of the Palæozoic or the commencement of the Mesozoic periods there appears to have been a further elevation of the continent, especially in the eastern part, for though in many places the deposits of the strata show little interruption, in others there has been considerable disturbance and unconformity of succession, with indications of an increase in the elevation of the land, which, with a contingent increase of rainfall, accounts for the luxuriant growth of the carbonaceous flora and its extension much further to the west. The artesian bores which have been made show that the cretaceous beds rest on the carbonaceous at a depth of 2000 feet below the present ocean level, and the fresh-water beds of the coal series are not less than 3000 feet in thickness, showing that the terrestrial level of the mountains has been decreased 5000 feet, or, in other words, they were 5000 feet higher during the Mesozoic period. On the western coast the elevation is not so well defined, but the land was at a greater height above the ocean than at present, as fragments of coal and its accompanying minerals have been washed up from the deep sea, and may be found embedded in the Tertiary limestones of the coast. There is thus proof that on the west coast the land extended further, and was covered with Australian fresh-water flora of the coal period; but this area is now submerged, and, taking into consideration the great depth of the ocean on this coast, the height of the land must have exceeded its present level by a thousand feet. Examining the ocean depths around the present Australian coast, even 5000 feet would make little difference in the limits of the west, south, and south-west shores; but on the north and east the land would extend to the Great Barrier Reef. Papua would have been annexed, and even the Arafura Sea and Island of Timor might have been brought within the limits of *Terra Australis*.

VEGETATION OF AUSTRALIA.

The mountain ranges of the east coast would be connected with those of Papua and form a magnificent series of summits of 10,000 feet elevation, a configuration that must have arrested the moisture from the Pacific Ocean, and resulted in a moist tropical climate, well calculated to support the luxuriant growth of the vegetation of the coal period so far as East Australia was affected, though it might also have had the effect of rendering the climate of Central and West Australia so dry as to render the land a desert during the continuance of this carbonaceous period. East Australia has thus, on its lower levels, accumulated stores of fuel for use in ages long subsequent. The luxuriant vegetation necessary to the production of coal was limited to the area east of the 140th meridian, except in a portion of South Australia, which seems to have been favoured by the overflow of some large rivers draining the western slopes of the Great Range, and had their outlet through Spencer's Gulf. The vegetation of Australia at this period, however well adapted for the formation of coal deposits, was not such as in the present would be suitable for the maintenance of mammalian life, as it consisted of ferns, cycadea, palms, and pine-trees, of which only the *Araucaria Bidwillii* has left a living representative, and its silicified wood from the coal formation presents exactly the same structure as the tree now growing on the ranges. Australian geography underwent little change during the Mesozoic period, but at the commencement of the Cretaceous a general subsidence of the whole continent began. The coal deposits ceased, and a fresh-water deposit known as the Rolling Downs formation accumulated, the constituents being soft shales, which in the earlier period supported a growth of ferns and pine timber. The land continued to subside until the ocean invaded a large portion of the lower lands, but only as a shallow sea, or possibly in the form of estuaries, as the fresh-water vegetation appears intercalated with marine limestones containing Ammonites and other mollusca of the Cretaceous epoch.

THE CRETACEOUS PERIOD.

The depression during the Cretaceous period must have been gradual and of long continuance. The ocean apparently first covered the land near the Great Australian Bight on the south, and Arnheim's Land on the north, as in each of these localities there are extensive deposits of thick bedded limestones, which may have continuity across the continent under cover of the ferruginous sandstones of the latter part of the epoch. On the east coast the ocean rose from 100 feet to 200 feet above its present level in Queensland, as the margin of the Cretaceous rocks is visible close to South Brisbane, and there is a belt along the coast from Point Danger to Gladstone. Further north there are extensive patches of Desert Sandstone belonging to this period, though the designation seems to have been applied to two distinct beds of sandstone, one belonging to the close of the Mesozoic, and the other to the last part of the Cretaceous.

GREAT DEPRESSION AND ERUPTIONS.

Ultimately the dry land was reduced to the eastern ranges, from Cape Howe northerly to lat. 15°; the eastern side nearly the same as the present coast-line, and extending from 100 to 300 miles westerly, while the Mount Lofty Range in South Australia existed as an island. This great depression was accompanied by dislocations of strata and also the eruption of porphyritic masses, the age of these eruptions being easily determined as they rest on the Ipswich coal strata. At Mount Flinders the base of the mountain consists of coal shales with abundant impressions of *Pecopteris*, while there is a more instructive instance near Teviot Brook, where in a deep ravine there is a dyke of porphyry cutting through a bed of carbonaceous shale with *Pecopteris* and the silicified stems of pine-trees embedded. The dyke itself is dark-coloured and highly crystalline, but where it spreads out into a flat sheet on the top of the hill it assumes the same appearance as the light-coloured porphyry of Brisbane. This porphyry forms the Glass-house Mountains, which are so conspicuous from the entrance of Moreton Bay, and also Mounts Warning, Leslie, Maroon, and Barney.

The central and western parts of the continent were almost entirely submerged in the ocean, but not to any great depth, as the higher granite peaks of the north-west do not show traces of submergence, though the sedimentary deposits approach closely to their bases. The Stirling and Mount Barren Ranges on the south coast were only partially covered, as there is an ancient sea beach on the south side of middle Mount Barren, about 300 feet above the present sea-level. The interior tableland, though now of greater altitude than Mount Barren, was submerged, as evidenced by the extension over the whole of the rest of West Australia of soft sandstones and claystones in which salt and

gypsum are of common occurrence. On the northern coast the submergence was greater, as the sandstones and shales have a thickness of more than a thousand feet.

THE CRETACEOUS DEPOSITS.

One characteristic of the later part of the Cretaceous deposits is that in the lower part they consist chiefly of white, blue, and pale red shales, which readily disintegrate, while the upper portion consists of variegated sandstones of a harder character, with a comparatively thin covering of ferruginous concretionary pebbles or nodules, often with a nucleus of organic origin. On the west coast (latitude 29°), on Moresby's Flat-topped Range, these features are well developed, and in the upper part a bed of limestone, containing Ammonites and other mollusca of the Cretaceous series. And it was from this locality that the first proofs of the existence of the Cretaceous formation in Australia were furnished to Prof. M'Coy. Closely associated with these limestones are ferruginous sandstones, containing casts of large accumulations of fragments of wood and vegetable débris, such as may be found after floods on the margins of rivers, indicating an estuarine system, where fresh and salt water alternated.

AUSTRALIA AN ISLAND.

The Mesozoic period closed with Australia reduced to the area of a large island on the east coast and some small islands on the south-west and north-west of the present continent, and then the connection with Papua was severed

A NEW ELEVATION.

Early in the Tertiary period a new elevation of the land commenced, but the rise was not attended by any great disturbance of the strata, as in almost every instance where the Upper Cretaceous rocks remain they are remarkable for their horizontal position. The elevation of the continent on this occasion was nearly equal in all parts; the ultimate altitude was at least 500 feet greater than at present, and the geographical effect was that Australia assumed nearly its present limits.

FEATURES OF THE CONTINENT.

The features of the continent at this time appear as high ranges on the east coast and a nearly level tableland extending to the west coast, but the whole of the interior with a general incline towards Spencer's Gulf. Short watercourses flowed direct to the sea, but far the greater area was drained by much longer streams towards Spencer's Gulf, while a secondary series occupied the basin of the Murray and Darling Rivers. The climate evidently differed greatly from that now existent, as the denudations of the tableland removed tracts of country many hundreds of square miles, each forming immense valleys bounded by flat-topped hills and ranges representing the marginal remnants of the original surface. Enormous quantities of the finer-grained portions of the degraded shales must have been swept into the ocean by the rivers, but the coarser sands have been left in what is now the desert interior, where the wind drifts it into long steep ridges of bright red sand, having a northerly direction near the south coast, but spreading out like a fan to the east and west in the northern interior.

VALLEYS AND RIVER SYSTEMS.

The interior rivers formed a grand feature of the country so long as the rainfall continued sufficiently copious to maintain their flow, but in the arid climate which now obtains it does not even compensate for the evaporation. The river channels have been nearly obliterated, and some parts of the wider valleys changed to salt marshes or lakes, such as Lakes Amadeus and Torrens, while the entrance to Spencer's Gulf is choked with sand. It was during this period when the great valleys of the river systems were being excavated that a great proportion of the outbursts of volcanic rock in the form of basalt occurred. The age of these basalts is established by their superposition on cretaceous rocks. Thus, at Roma, the Grafton Range is a mass of basalt, resting on the cretaceous sandstones and shales. Mount Bindango is a similar instance. On the Upper Warrego there is a deep ravine through cretaceous rocks partly undermining a basaltic cone. On the Victoria River a large basin has been eroded in the cretaceous rocks and then several hundred square miles flooded by an eruption of basalt, through which watercourses have cut instructive sections, showing the subordinate sandstones baked and fused by contact and the cracks filled by the covering basalt.

It does not appear that the eruption of basalt has materially affected the geographical outline of the coast, but there were considerable variations of level and important tracts of fertile country formed by the basaltic detritus, such as Peak Downs and Darling Downs in Queensland, and to the west of Melbourne in the south.

LARGE ANIMAL PERIOD.

It was not till after the convulsions which attended this outflow of basalt, and lakes, marshes, and rivers had been formed, and produced a luxuriant growth of vegetation, that the gigantic marsupials gave any decisive evidence of their advent, as their fossil remains are found in the drifts of watercourses mixed with basaltic pebbles and detritus. The physical conditions of the country during the period of the Diprotodon, Nototherium, and associated fauna, differed materially from that which now subsists, for the structure of the larger quadrupeds would render them incapable of obtaining a subsistence from the short herbage now existing in the same localities, and it is evident that their food was of a large succulent growth, such as is found only in moist climates and marshy land or lake margins. This view is also supported by the fact that on the Darling Downs and Peak Downs the associated fossils include crocodile and turtle, so that what are now open grassy plains must have been lakes or swamps, into which the streams from the adjacent basaltic hills flowed, and, gradually filling the hollows with detritus, formed level plains.

ENORMOUS RAINFALLS.

That this gradual filling up of lakes actually occurred is shown by the beds of drift which are found in sinking wells and in sections exposed by erosion of watercourses; but in all these instances there is evidence that the ancient rainfall was excessive, as even our present wettest seasons are inadequate to the removal of the quantities of drift which have been the result of a single flood in the ancient period. On the ridges around the lakes there existed a forest growth, as many species of opossum have left their bones as evidence; but the timber evidently differed from the present scanty growth of eucalypti. Whether the same abundant rainfall extended far into the western interior is uncertain, but the rivers evidently maintained a luxuriant vegetation adapted to the sustenance of these gigantic animals, as the discovery of a nearly complete skeleton of Diprotodon on the shore of Lake Mulligan, in South Australia, shows that these animals lived in this locality, as it is not probable that their bodies could have floated down the Great River which drained the interior of the continent through Lake Eyre.

ANOTHER CHANGE.

It is evident that the climate gradually became drier, that the rivers nearly ceased their flow, and the lakes and marshes became dry land, while the vegetation was reduced to short grasses that no longer sufficed for the subsistence of the huge Diprotodon and gigantic kangaroo, though some of the smaller may still survive to keep company with the dingo, who, while he left the impressions of his teeth in the bones of the Diprotodon, has shown a greater facility for adapting himself to altered conditions. Is this the survival of the fittest? It was in these days that some of the rivers flowing direct to the coast cut through the sandstones into the softer shales beneath, and by their erosion formed considerable valleys bounded by rocky cliffs, and when the land was subsequently depressed the sea flowed in and formed inlets, of which Sydney Harbour and the entrance to the Hawkesbury River on the east coast, Port Darwin and Cambridge Gulf on the north-west, and the Pallinup River on the south-west of the continent may be cited as examples.

CONCLUSION.

Thus Australia, after its first appearance in the form of a group of small lands on the east, and a larger island on the west, was raised at the close of the Palæozoic period into a continent of at least double its present area, including Papua, and with a mountain range of great altitude. In the Mesozoic times, after a grand growth of vegetation which formed its coal beds, it was destined to be almost entirely submerged in the Cretaceous sea, but was again resuscitated in the Tertiary period with the geographical form it now presents. Thus its climate at the time of this last elevation maintained a magnificent system of rivers, which drained the interior into Spencer's Gulf, but the gradual decrease in rainfall has dried up these watercourses, and their channels have been nearly obliterated, and the country changed from one of great fertility to a comparatively desert interior which can only be partially reclaimed by the deep boring of artesian walls.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

CAMBRIDGE.—The preliminary resolutions in reference to the admission of graduates of other Universities to courses of advanced study and research were passed *nem. con.* by the Senate on April 25. The Syndicate for the purpose will now proceed to frame the detailed regulations for carrying the scheme into effect.

An Exhibition of fifty guineas a year for three years is offered by the Clothworkers' Company for the encouragement of Physical Science. Candidates must be non-collegiate students of one term's standing, or persons not yet in residence who propose to become non-collegiate students next October. The examination will be held next July. Information as to conditions, &c., may be obtained from the Censor, Fitzwilliam Hall, Cambridge.

SOCIETIES AND ACADEMIES.

PARIS.

Academy of Sciences, April 22.—M. Marey in the chair.—On the effects of the air carried below, without gyration, in the interior of tempests, water-spouts, and tornados, by M. H. Faye. The author shows that water-spouts are of the same type as, though on a smaller scale than, cyclones and typhoons. He illustrates by an experiment the character of the air-movements in the case of a water-spout. A gyratory movement at the base of a cloud causes the formation of a descending cone which has no effect below until the apex reaches the ground or water, when the air from above carried down in the centre of the cone escapes with violence in every direction. The phenomenon consists then of an interior comparatively calm core, down which proceeds air from the upper regions, and this is surrounded by a shell of cloud having a rapid rotatory motion. The analogy of the air-movements in cyclones and typhoons is brought out by a detailed consideration of (1) a storm encountered by the corvette *l'Églé*. (2) a typhoon which passed centrally over Manilla Observatory on October 20, 1882. The calm column in the latter case was much hotter (11°) and drier than the surrounding shell of storm: the direction and force o the wind, temperature, and humidity were continuously registered, and completely bear out the explanation advanced.—On a new type of wells in the granitic rocks of Sweden, by M. Nordenskiöld. These are artesian wells bored to a depth of from 30 to 50 metres in solid crystalline rocks in the hope of meeting with water coming through horizontal cracks expected to occur in the mass owing to the variations of temperature suffered by the surface portions. Such cracks supplying sweet water have invariably been encountered at a depth of 33 to 35 metres.—On a new deposit containing uranium, by M. Nordenskiöld. A uraniferous substance giving nitrogen (see "Notes," p. 8). Crystals forming at the bottom of a solution of greater specific gravity than themselves, by M. Lecoq de Boisbaudran. The inverse effect to that previously described by the author, where substances were shown to crystallise under some circumstances at the top of solutions of less specific gravity than the crystals. Crystals of sodium sulphate, floating on a solution of sodium iodide saturated with the sulphate, gradually disappeared, re-crystallising around a sulphate crystal previously fixed at the bottom of the solution. The same phenomenon occurs with ice in a dilute ammoniacal solution. This action depends on small temperature variations, as previously explained.—Every algebraical surface may be described by means of an articulated system, by M. G. Kœnigs.—On curves of the fourth class, by M. Georges Humbert.—On the dilatation of water, by M. Stéphane de Lannoy. The author discusses the dilatometer method of taking the expansion of water, and tabulates his results with three instruments. A table is then given comparing the mean results with Rosetti's values, and with the corresponding quantities calculated from these values for the same temperatures by the air-thermometer.—Specific heat and boiling-point of carbon, by M. J. Violle. Above 1000° C. the mean specific heat of graphite increases linearly with the temperature, thus—$C_0^t = 0{\cdot}355 + 0{\cdot}00006t$. 2050 calories are given up by 1 gram of graphite on cooling from the volatilisation temperature to 0°. The temperature of ebullition must therefore be 3600° C.—Electric resistance at the contact of two metals, by M. Edouard Branly. It is shown that certain pairs of metals, such as copper-zinc, have no contact resistance, whereas other pairs, lead-aluminium, lead-iron, tin-aluminium, tin-iron, bismuth-iron, bismuth-aluminium for instance, have an electric contact resistance.—On an optical method of studying alternating currents, by M. J. Pionchon.—On photography in natural colours, by the indirect method, by MM. Auguste and Louis Lumière. Several negatives are prepared with differently coloured screens, and each is used to print off in a layer of the appropriately tinted bichromated-gelatine.—Molecular rotation and molecular deviation, by M. Ph. A. Guye.—On some derivatives of quinone-diorthoamido-benzoic acid, $C_6H_2O_2(NH.C_6H_4.CO_2H)_2$, by MM. J. Ville and Ch. Astre.—Remarks on the *pars intermedia* of Weisberg, by M. A. Cannieu.—On the absorbent power of the bladder in man, by MM. A. Pousson and C. Sigalas. Healthy vesical epithelium is impermeable in general, but absorption may take place (1) when the subject with a healthy bladder requires to void its contents, the urine then bathing the prostatic portion of the urethra; (2) when the vesical epithelium is altered.—On the seat of the colouration of brown oysters, by M. Joannes Chatin.—On the presence of a diastase in *vins cassés*, by M. G. Gouirand.

Erratum.—In the last report, p. 622, line 19 from bottom of second column, "left-handed" curves should read "skew" curves.

BOOKS, PAMPHLETS, and SERIALS RECEIVED.

BOOKS.—Anales del Museo de la Plata. Paleontologia Argentina, ii. and iii. (Contributions to a Knowledge of the Fossil Vertebrates of Argentina): R. Lydekker (La Plata).—A Manual of Forestry: Prof. W. Schlich. Vol. 3: Forest Management (Bradbury).—Organic Chemistry: Prof. I. S. Scarf (Collins).

PAMPHLETS.—Catalogue of the Michigan Mining School, 1892-4 (Houghton).—City and Guilds of London Institute Report, March (London).—An Historical and Descriptive Account of the Field Columbian Museum (Chicago).—Sixty-third Annual Report of the Royal Zoological Society of Ireland (Dublin).—Science and Art Museum, Dublin, Art and Industrial Department. Collection of Weapons, &c., chiefly from the South Sea Islands, deposited in the Museum by the Board of Trinity College, Dublin, July 1894 (Dublin).—On the Relation of Diseases of the Spinal Cord to the Distribution and Lesions of the Spinal Blood-Vessels: Dr. R. T. Williamson (Lewis).—The Federated Institution of Mining Engineers. Report of the Proceedings of the Conference on Inland Navigation, Birmingham, February 12, 1895 (Newcastle-upon-Tyne).—Temperaturmaalinger, i. Lofoten, 1891-1892 (Christiania, Werner).

SERIALS.—Mittheilungen der Hamburger Sternwarte, Nos. 1 and 2 (Hamburg).—English Illustrated Magazine, May (Strand).—Longman's Magazine, May (Longmans).—Good Words, May (Isbister).—Sunday Magazine, May (Isbister).—Quarterly Review, April (Murray).—American Journal of Mathematics, April (Baltimore).—London Catalogue of British Plants, Part 1, 9th edition (Bell).—Journal of the Institution of Electrical Engineers, April (Spon).—Journal of the Royal Microscopical Society, April (Williams).—Bulletin of the American Museum of Natural History, Vol. 6, 1894 (New York).—Natural Science, May (Rait).—Century Magazine, May (Unwin).—Contemporary Review, May (Isbister).—National Review, May (Arnold).

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